THE McGRAW-HILL MAGAZINE FOR DESIGN ENGINEERS

DEC 11, 1961

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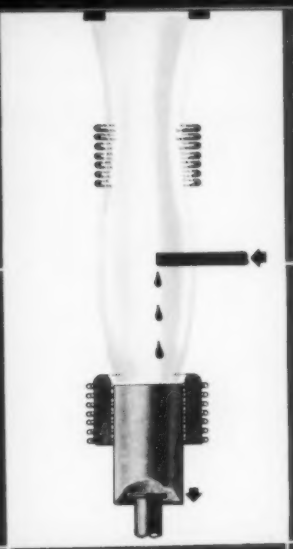

MELTING

Electron-beam plasma competes successfully with vacuum-arc or sintered powder methods to produce high-purity alloys.

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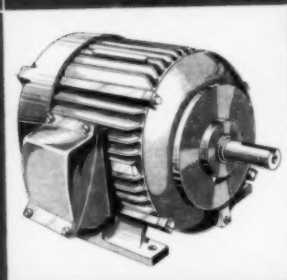
PRODUCT ENGINEERING

MOTORS



Higher temperature insulation increases overload margin 15% to give enclosed motors the same capacity as open motors.

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ADHESIVES

Simple-to-apply films will lower costs and give higher-strength joints, improved reliability, closer tolerances.

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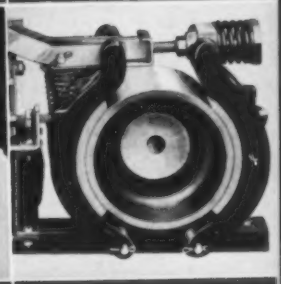
BRAKES



Which electric brake? These comparison tables and charts will help select the smallest one to do the job.

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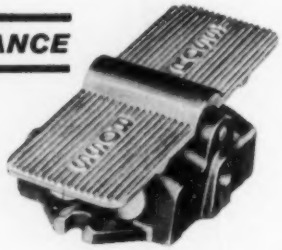
The world's largest line of air valves is also the most advanced because of the Ross engineering staff

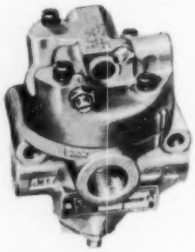
Do you know these Ross air controls?

EASY MAINTENANCE



Rugged, dependable foot valve

The 600 valve series. Features maintenance without disconnecting piping, rugged construction and a variety of treadle options: double or single treadle; spring return or detent. Also available as a hand valve. 3-Way and 4-Way models, ¼".



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The Ross Graymodel Valve is actuated by pilot air from another part of the circuit. Times in with cartridge in one position, times out if cartridge is reversed. Adjustable to 0 to 3 second delay.

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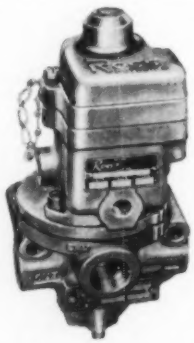

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Pneumatic system calculations depend on manufacturers' specs which are not always compatible. Here's how to make them work together in flow computations.

A new cam profile

This family of cam curves is designed to operate below the natural frequency of the follower system and thus avoid resonance.

To be a boss

You'll need new skills, new viewpoints, if you intend to switch from technical work to a managerial position. Are you sure you're ready?

Low-cost latches

Here are six ways to hold a box cover down that are simple and inexpensive—though they may look it.

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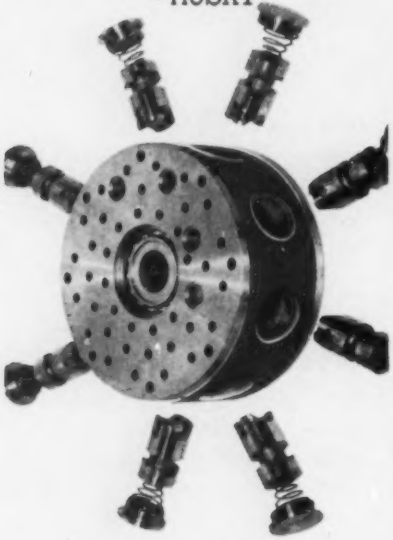

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CIMTROL

INTERESTING TO NOTE

IN THE early part of the 19th century, stopping a railroad train was a clumsy and uncertain business. A brakeman rode on each car and frantically turned a large handwheel in response to blasts on the engineers whistle. Then, in 1872, George Westinghouse introduced his air brake which, unlike most new inventions, was almost immediately adopted by the railroads. The reason for its fast acceptance is often traced to a fortuitous accident. To us it looks more like the work of an astute publicity man but, in any event, it makes a good story.

According to the legend, Westinghouse borrowed a locomotive and four cars, which he equipped with his ingenious braking system. Then, inviting prominent railway officials as witnesses, he packed them aboard the cars and took off for the first station on the scheduled run. Despite warnings that the tests of an experimental brake were in progress, a farmer attempted to cross the track with his team and wagon and soon found himself stalled across the rails. With the train bearing down, the horses fled, upsetting the wagon and throwing the farmer onto the track. The engineer, who had been considering the best way to bring the train to a smooth halt at the next station, reached quickly for the air valve. The train stopped four feet short of the unconscious wagon driver.

Railroad officials, though momentarily upset by the sudden stop, were much impressed. So impressed, in fact, that the Westinghouse Air Brake Company was almost immediately capitalized at $500,000 and its young founder (he was then only 23) launched on his successful career.

In this first Westinghouse design, the compressed air, which came from a reservoir, forced the shoes against the drum. In later designs, he reversed the scheme of things into the form we know today, with the compressed air holding spring-loaded shoes away from the drum. With this improvement, runaway cars stop automatically when the air line is broken and brake failure in one car does not interfere with other cars.

In Westinghouse's time, compressed air seemed to be the only way to communicate a braking signal to a long string of cars. A designer faced by the same problem today might well consider an electric signal activating electric brakes. For a roundup of the electrically operated brakes our designer would have to choose from, see page 66.

From McGuffey to the self-starter

Current controversy over McGuffey's Readers (some educators feel that stories with morals are unsuitable) recalls that Charles Kettering claimed again and again that his exposure to the series had been very important in shaping his own philosophy. Remember, "where there's a will, there's a way"? This became in Kettering's words, "we can overcome the difficulties if we want to."

Charlie Kettering was born in northern Ohio, and went to country schools there for years. He was a farmer's son, nearsighted, and without money for glasses, so he held his McGuffey's pretty close to his nose. He was kidded by other youngsters for this and his shambling gait. But he didn't care; he went on to school, showed brilliance in math and physics, studied the Corliss at the flour mill on his way to and from school, fastened his Latin grammar on the plow handles so he could work and study. He was a questioning nuisance in class; there were many questions before he asked his famous, "Why is the grass green?" —and went on to find out.

continued, page 6

Snowplow chews up avalanches at 36 tons a minute

How steel with Nickel in it delivers the brawn behind the bite

Chewing through mountainous drifts to rescue a snow-bound town, this plow can devour 2,200 tons of snow an hour.

It bites through solid ice and deep snow. Or strips a new-fallen six-inch blanket from a superhighway at 30 mph.

Drive shaft and gears run a gauntlet of shocks as the plow churns through rocks and stumps buried under stone-hard snow. That's one big reason why two nickel alloy steels, AISI 4320 and 3140, are used for these heavily stressed transmission parts.

Nickel gives steel the strength and toughness essential to a snowplow's drive shaft that must perform under brutal wrenching, twisting shock loads in arctic cold.

Putting stamina where it counts is just one of the things you can do with Nickel. In addition to providing muscle, Nickel can also help alloys withstand the intense heat generated by supersonic flight. Or shrug off the deep cold of liquid helium. And every industry knows the value of Nickel in combatting corrosion.

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Transmission shafts are made of AISI 4320 nickel alloy steel. Drive and spline bushings are AISI 3140. Snowplow by American Snowblast Corp., Denver, Colorado.

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VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

INTERESTING TO NOTE *continued*

His parents wanted him to be a minister, and he tried it to the extent of spending a summer studying Greek. But his eye trouble flared up. He taught country school, then town school. At the same time, he was doing chemical and electrical experiments at the local drugstore and picking up engineering ideas from a local wagonmaker. So he went to college to study engineering. His eyes kicked up again and again, and for a while he had to leave school—to set telephone poles and ultimately install telephone exchanges. Finally, he got his degree.

The rest is history. But the basic point is that "Boss Ket" was a typical creative man (see page 63), exhibiting at one time or another all the characteristics that distinguish the breed. His curiosity was insatiable, his interests broad, and the difficulties he faced helped him to go where he wanted to go. (Kettering's biography, "Professional Amateur," is available in a special PE paperback. Just send a dollar to Reader's Service, Product Engineering, 330 W 42nd St, New York 36.)

A name for stickum that stuck

According to today's authorities, choosing a descriptive tradename for a product is a ticklish business worthy of a company's best creative effort. The name, they say, influences the buyer's image of the product. In 1920 corporations were less concerned with images, and tradenames were chosen with much less deliberation. One of the most famous—and still one of the most valuable—wasn't even chosen; it just happened.

Executives of the 3M company aren't even certain where their famous tradename "Scotch Brand" originated. One legend has it that the name started as a nickname coined by some of the first users of pressure-sensitive tapes. At that time, 3M was making a kind of masking tape for auto paint shops (their cellophane tape didn't appear until two or three years later). The tape came in rolls two inches wide and had an adhesive coating only on the borders of the strip; the center was left uncoated. It was intended that auto painters would stick one edge to the car, outlining the area to be masked, while attaching the other edge to large sheets of masking paper. But the partially coated tape didn't adhere well. According to the story, the painters suspected 3M of being scotch with their adhesive and began referring to it as "that Scotch tape". The name caught on and soon the tape was officially trademarked "Scotch Brand" tape. When the pressure-sensitive cellophane tape came along several years later, it was natural to apply the same trademark to it. For a look at some modern film adhesives, see the article which begins on page 86.

Sharper than a razor's edge

Japanese, in the year 1600, had excellent steel from which their *samurai* swords were made. The steel was so good that it resisted nicking, even though the edge on swords was honed so fine (and the swordsman's hand so steady) that an apple set on a man's forearm could be split without touching the man's arm. Clothing could be cut without touching the skin beneath, silk scarves parted under their own weight.

All this was reported in the diaries of William Adams, an English sailing master and sea captain. Adams arrived in Japan in April of 1600, without charts and sailing a Dutch ship. The ship was the last of seven that had left Holland two years earlier, and carried only 24 of its original crew of 496. Originally a captive, he soon became the right-hand man of the *shogun* (temporary ruler under the emperor), and stayed on as "Daishi-san." There is still a Tokyo street named after Adams and two shrines in other Japanese cities.

We were reminded of Adams' account of the extraordinary Japanese steel in connection with our article on electron beam melting (see page 78). With this modern tool, we can make metals that retain their properties up to red heat and we can melt them without oxidation. Whether we can make a sword that will part scarves by their own weight is open to question. Maybe we need heavier scarves.

FLANGE PROJECTIONS improve TORQUE RETENTION

Here's a simple, economical, and widely adaptable way to build elasticity into rigid flange-bolt assemblies . . . and get better torque retention.

E. M. SMOLEY, Research Physicist, Armstrong Research and Development Center

To minimize loss of bolt torque in rigid gasketed joints, design engineers try to introduce some elasticity into the flange-bolt system.

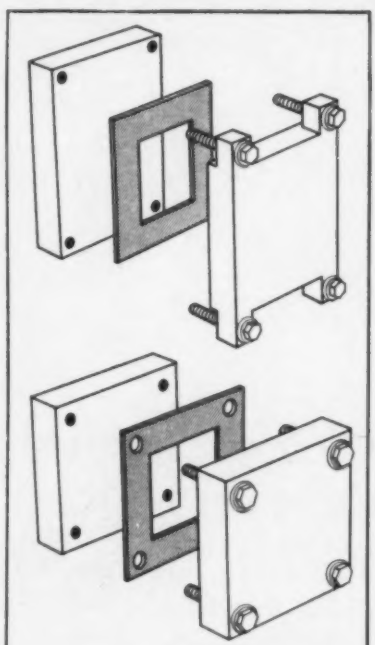

Figure 1-a (Top): Test flange with gasket. Note cantilevered projections for bolt holes. Flanges 1" thick, with gasket area 4" square.

Figure 1-b (Bottom): Control flange with gasket area 4" square.

One way to do this is to use the longest bolts possible, torqued close to their recommended limits. The elasticity of the bolts (the so-called "spring effect") then acts to compensate for compression drift and the effects of thermal expansion.

In most applications, however, long bolts are either impractical or uneconomical. As alternates, designers may use spring-loaded bolts or through bolts with nuts. These will usually produce the desired elasticity, but they increase parts costs and add to assembly time.

Armstrong research engineers suggest the use of cantilevered projections as a simple, economical, and widely adaptable way of building elasticity into a rigid flange.

Figure 1-a shows a laboratory design of such a flange. The machined projections through which the bolts pass do not contact the bottom flange. As the bolts are tightened, the projections deflect slightly, introducing elasticity through the flange instead of through the bolts.

This design was tested extensively at the Armstrong Research and Development Center. A control flange of identical size except for the projections was tested simultaneously (Figure 1-b).

Both flanges were gasketed with an Armstrong Accopac® asbestos material (1/32") and assembled with four 5/16" NF bolts. In the initial test, all bolts were torqued to 5 pound-feet, and both assemblies were placed in a 300° F. oven.

After 18 hours, retained torque was measured (1) while the flanges were still hot; and (2) when they had cooled to room temperature.

The test was repeated, increasing the torque in increments of 5 pound-feet up to 25 pound-feet. A summary of the test data is given in Figure 2.

TORQUE RETENTION

POUND FEET INITIAL TORQUE	HOT TORQUE		COLD TORQUE	
	CONTROL	TEST	CONTROL	TEST
5	3.6	4.5	3.0	3.6
10	6.4	9.8	6.2	8.9
15	10.0	14.4	10.0	14.0
20	14.8	20.2	13.2	19.6
25	18.2	25.6	18.2	24.8

Figure 2: Results of flange projection study. Hot torque measured after 18 hours at 300° F. Cold torque measured after cooling to room temperature. Accopac AN-890 asbestos gasket (1/32") in flanges.

In every case, the test flange shows a higher torque retention—hot or cold—than the control flange. At loads of 15, 20, and 25 pound-feet, practically 100% of the initial torque load was retained on the test flange.

Research on problems of gasket selection, design, and performance is a continuing project at the Armstrong Research and Development Center. Our large library of data may already contain answers to your specific sealing problems. We will be glad to make suggestions if you will send details to us. Armstrong Cork Company, 7112 Irvin Street, Lancaster, Pa.

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says Robert Troxell, Relay Engineer, Cook Electric Company, Chicago, Illinois

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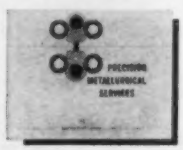

For additional information on Hamilton's facilities and capabilities, send for free booklet, "Precision Metallurgical Services." Write Dept. 3512, Metals and Electronics Div., Hamilton Watch Co., Lancaster, Penna.

HAMILTON WATCH COMPANY

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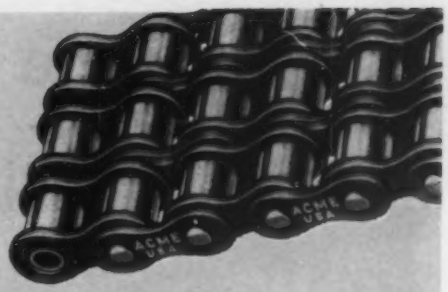
MULTIPLE ROLLER CHAINS

Multiple roller chains of double, triple and quadruple widths in all standard pitches in riveted types are ordinarily carried in stock — multiple chains up to 6 strands or wider can be furnished.



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for every

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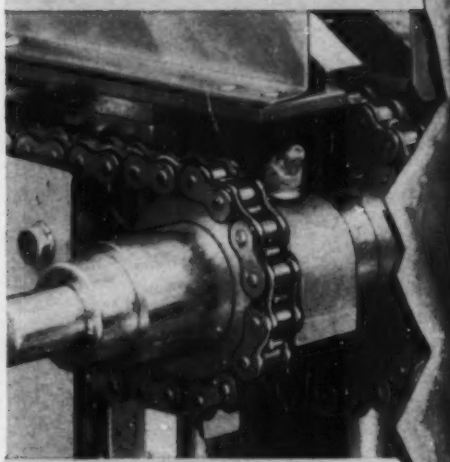
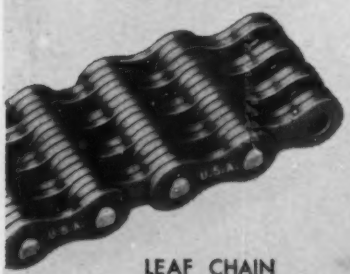
ACME Roller Chains are designed and built to perform each specific job with maximum efficiency and economy. Sprocket ratio, chain impact, tension, drive speed and other factors are determined, not on the drawing board alone, but in the field where ACME Engineers observe and test chains at work while new equipment is being designed. In that way, ACME chains are made to deliver positive power transmission with economy and dependability under all loads at all times.

For maximum performance at low transmission cost, be sure to specify ACME Roller Chains. They will give you the most value for your chain money. Call your ACME Distributor.

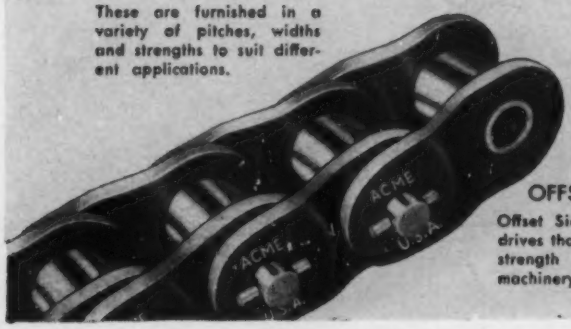


This shows a typical installation with positive power transmission where long life is essential.



LEAF CHAIN

These are furnished in a variety of pitches, widths and strengths to suit different applications.



OFFSET CHAIN

Offset Side Bar Chains for drives that require herculean strength in construction machinery and oil fields.

EXTENDED PITCH CHAIN

Extended pitch chains are becoming increasingly more popular in many industries where high grade finished roller chains are required, at a lower cost than the standard pitch chains.

Write Dept. 1-X for new illustrated 106 page catalog with engineering section.

Acme Chain Corporation
Holyoke
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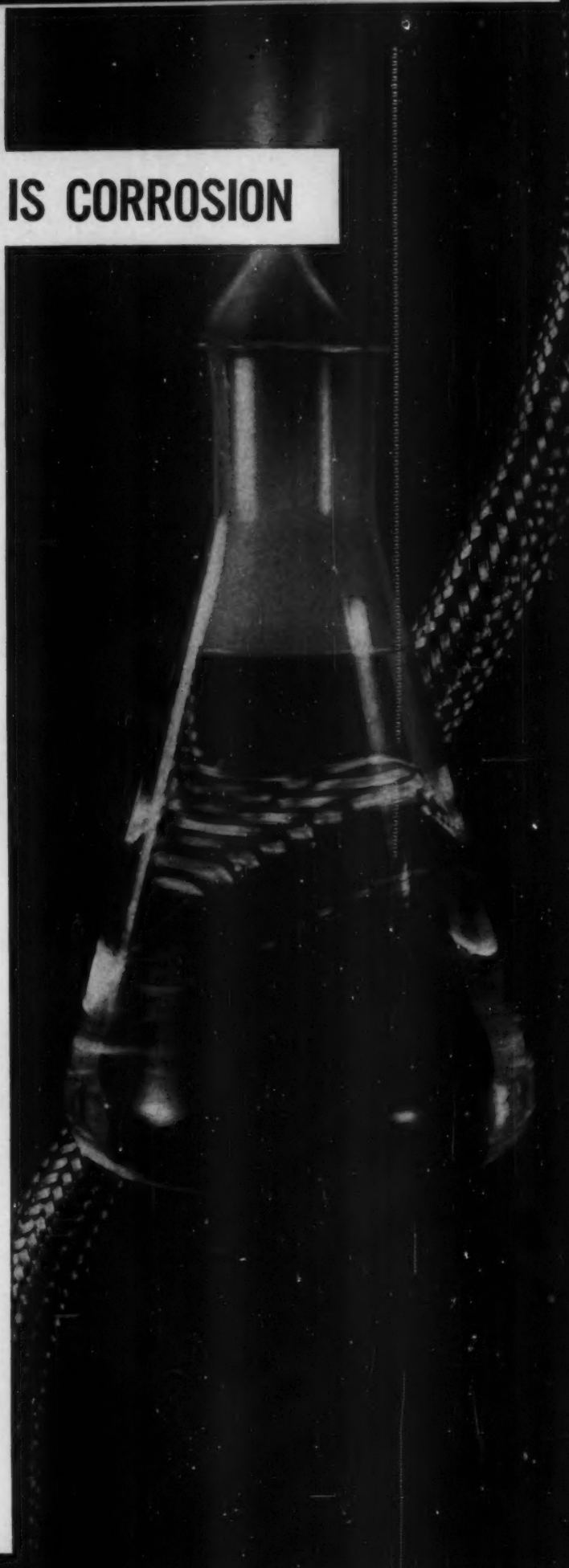
inside/outside

WHEN THE PROBLEM IS CORROSION

count on Anaconda hose of Teflon



If you're faced with the problems of corrosive atmospheres or of conveying corrosives, specify hose of Teflon* by Anaconda. These rugged, resilient connectors are being used to convey chemicals, steam, hot water, fuels, air, gas, liquids, semi-solids, and have proved the ultimate in durability and dependability. They are lightweight, flexible and serviceable at temperatures from −65° F to 450° F.

Whenever you have a connector problem, consult Anaconda. Select from hose in a wide variety of metals and materials meeting every requirement. Fast delivery from local distributor stocks. For more information write: Anaconda Metal Hose Division, Anaconda American Brass Co., P.O. Box 791, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 61-939

*Teflon is a DuPont trademark

ANACONDA®
METAL HOSE DIVISION

HORIZONS

No challenge?

"A subscriber" in New Orleans writes:

Although I'm a nuts and bolts engineer and far removed from anything to do with the space field, my curiosity continues to be aroused by the readiness with which the US accepts Russian claims as to the weight of their satellites. If I understand the physics correctly, practically speaking, weight has nothing to do with the characteristics of the orbit, once it is attained. Therefore, it seemed to me that this acceptance must come through information gained through Intelligence. One wonders if any nation's Intelligence is so good that it can verify Russian reports to the last pound. Two other items have clouded my view: One was a recently reported (on network TV) theory that the Russians use a saucer-like ramp to get part of their velocity. This would evidently reduce thrust requirements. Since Russian rocket thrust claims have been accepted completely for years, why would this theory even be put forward at such a late date? The other item which bothers me is this statement from King-Hele's Satellites and Scientific Research: "A few thoroughly skeptical voices proclaimed the Sputnik was not there at all, while a strong chorus tried to prove that the weight was 18.4 *lb, not* 184 *lb." I assume at least some of that chorus must have been scientists and their argument based on the actual orbit of the first Sputnik. Again, the tie-in between orbit and weight is confusing.*

We usually disregard anonymous letters, but this one raised a legitimate question that we've been asking ourselves. What specifications are used by our space scientists to judge the truth of Russian claims? So we passed the letter on to the National Aeronautics and Space Administration. This is their reply:

The following statement has been made by Mr James E Webb, Administrator, NASA, concerning the Soviet Union's announcements of manned flights:

> *"First, we have no reason to disbelieve it. Second, all the information that we have indicates that they have accomplished what they have announced they have accomplished.*
>
> *"I have stated that all the information that we have in this government gives no reason to disbelieve it and, in fact, confirms it."*

This agency has no information to indicate that the Soviets have used anything other than a conventional vertical launch pad similar to those used by the United States for any of their launches.

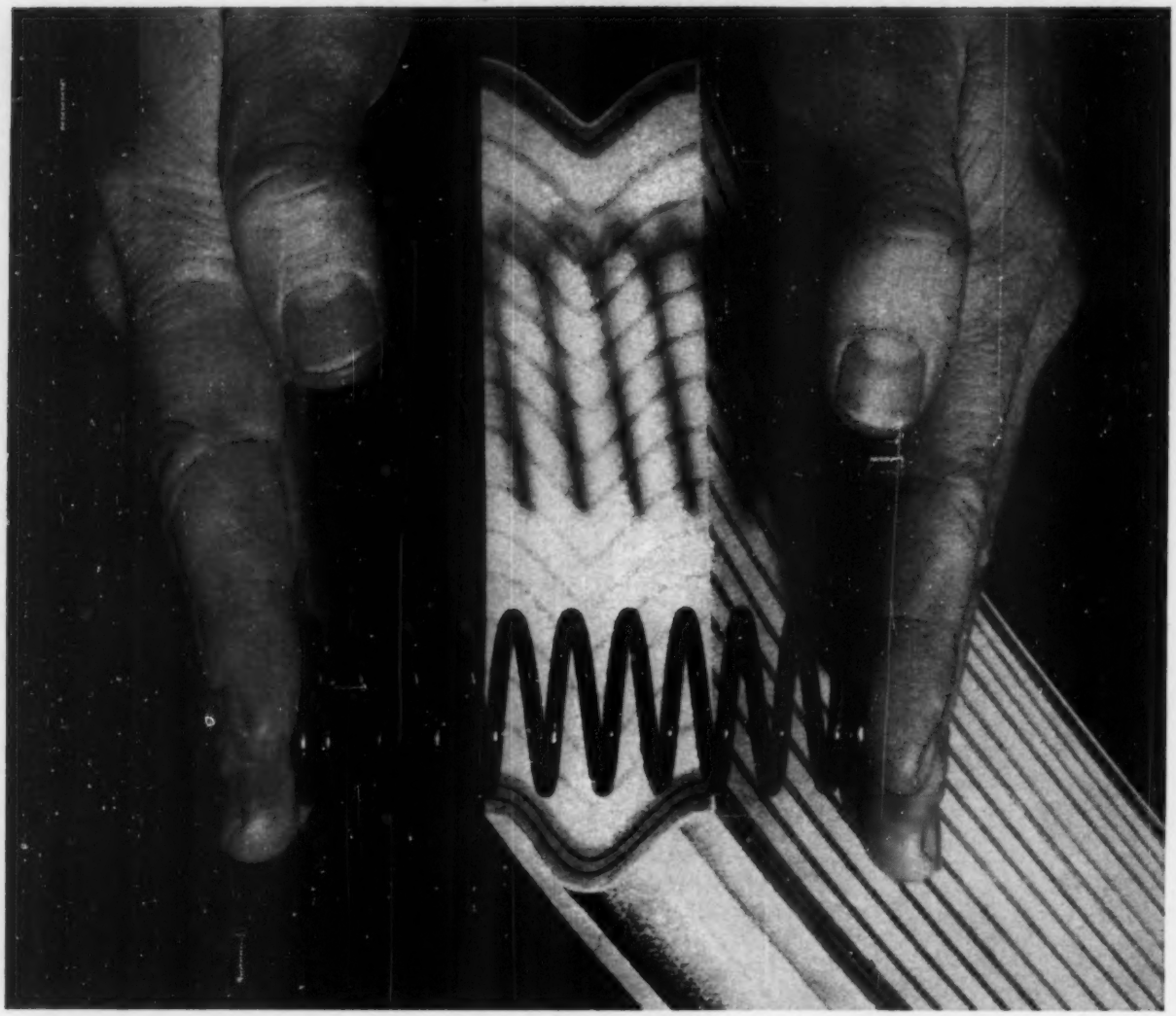
Here, stated twice by Mr. Webb, is the fact that we don't really know—we only assume that what we've heard is true.

It may well be; reason and experience suggest that it is. But the characteristic that the scientist and the engineer have in common is that we challenge even natural "laws". We do not accept other men's new evidence without test, nor new formulae without check. Presumably, there are men in NASA who have made such tests and checks in this case. And the CIA should have checked the subject out long ago. Wouldn't it have done a lot of good for our morale (and world opinion) to let us know on precisely what we base our acceptance of the facts? Or must this also be withheld from the public as a "military secret," in line with our apparent policy of admitting only our mistakes and allowing all worthwhile (and some very incautious) data on defense to issue from Congressmen making political speeches?

The fact is that Soviet security is little better than our own. Russian newspapers, for example, contain a great deal more information than you might expect.

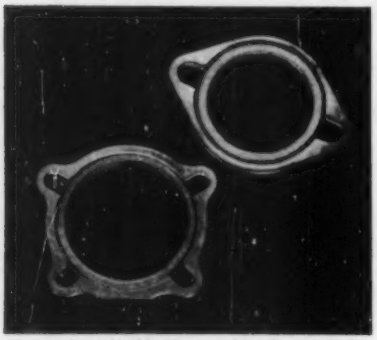
Take as a case in point the much-propagandized improvement in Soviet steelmaking—highly mechanized production at high efficiency. But *Trud* (Moscow) for July 19 talks of the Alapayezk Steel Combine and the method of making ingots. The author says that after pouring, the ingots are stripped from the mold (Russian word: undressing) then workmen run away to get some air into their lungs. Then they don wooden shoes and walk back over the ingots to straighten them.

Conditions in steel mills have, in fact, been so bad that the Central Institute has recommended 38 major improvements. Of these, 24 were accepted by mill management, but only four have been tried and only two are working. Does this sound like an economy that will "bury" us?



"Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.



Examples of wide range of styles available

This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 359, New York 16, N. Y. In Canada: Port Credit, Ontario.

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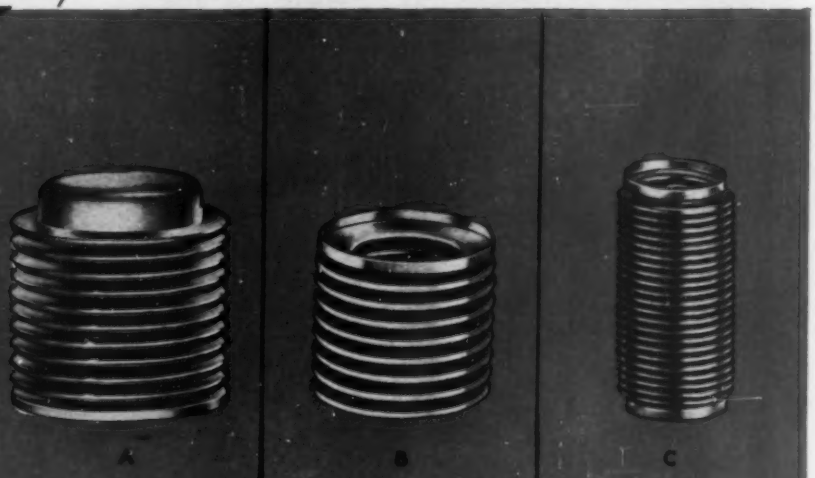
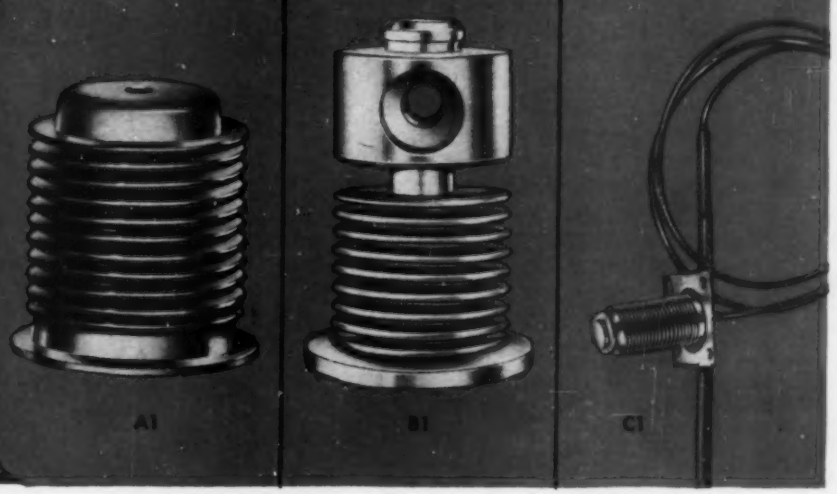
bellows



bellows assemblies



Uniformity of effective area and spring rate . . . adaptability to a wide variety of fittings . . . a broad range of sizes and materials . . . and proved long cycle life. These are sound reasons why leading manufacturers specify Flexonics bellows for temperature and pressure measurement, shaft sealing, even transmitting low-torque rotary motion. Important, too, is that the majority of these companies rely on Flexonics to furnish the complete bellows assembly. They have learned that the delicate and intricate operation of applying fittings by circular resistance welding, inert arc welding, silver brazing and soft soldering can be more ably performed by Flexonics highly skilled technicians. Full responsibility is with one source. Call on your Flexonics bellows expert or write for Flexonics Design Guide Number 231.

B-648

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FLEXIBLE METAL and SYNTHETIC HOSE
EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

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Please send my personal copy of Flexonics Bellows Design Guide No. 231, covering in detail Flexonics products and service for bellows application.

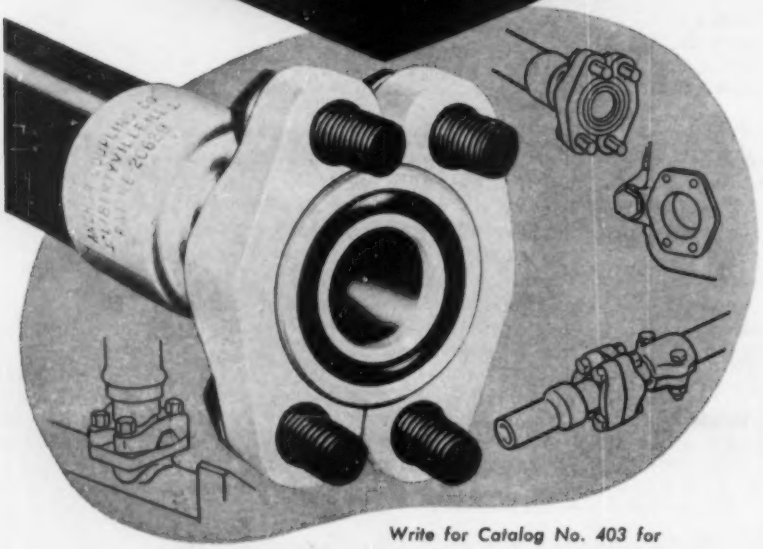
ANCHOR® THE PLEDGE OF PERFORMANCE

DEPEND ON IT!

ANCHOR (Patented) FLANCO® ASSEMBLIES

—eliminate costly pipe threading operations and separate union and swivel connections.

Anchor SAE 4-Bolt Split-Flange Halves and FLANCO "O" Ring Flanged Head Assemblies—available for use with Pressed-On and Clamp-Type Reusable Couplings, and Weld-Type Fittings—offer a new simplicity in connecting hose assemblies to valve or pump parts, to manifolds, from pipe to pipe, pipe to hose or hose to hose. They may be disconnected or reconnected time after time without danger of leaks . . . there are no threads to wear out, no tapered seats to groove. The patented design principle of Anchor's Split-Flange Halves prevents tilting of the clamp half and extrusion of the "O" Ring . . . design completely conforms to SAE Standards. Use of the highly efficient and widely used static "O" Ring seal eliminates the use of gaskets, tapered threads and sealing compounds . . . the "O" Ring seals the connection tighter as the pressure increases, there are no spiral leakage paths. Only ordinary automotive type wrenches are required to make up a FLANCO Assembly. Be sure . . . depend on Anchor FLANCO Hose Assemblies.



Write for Catalog No. 403 for complete description and specifications.

ANCHOR Coupling Co. Inc.

380 North Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

READER TO EDITOR

A different actuator

To the Editor:

We have read your article on linear actuators (PE—Sept 18, p 86). Under mechanical actuators you covered the ball leadscrew with motor drive which is used in a good many machine-tool applications, also is available as a complete package from some electric-actuator manufacturers. We would like to point out that in this area we offer a linear actuator of slightly different design. Our electric linear actuator is described in a new-product release in *PE—July* 10 '61, *p* 82.

—W. P. GETTELMAN
Jordan Controls, Inc.
Milwaukee, Wis

Big, bigger, biggest

To the Editor:

I wish to take exception to R J Ward, Jr, when he states (*PE—Oct* 16 '61, *p* 106) that 200-in. is the largest machine for spinning bulkheads. Alliance Machine Company built a 276-in. machine for Lukens Steel Company, Coatesville, Penna, about 15 years ago. —MILO SHUTT
Union Industrial Co
(Div Alliance Machine Co)
Alliance, Ohio

• The 276-in. flanging machine is very familiar to anyone who has visited Lukens, was frequently pictured at the time it was built. In contrast to the usual smaller spinning machine, which is essentially an engine lathe, this one looks like a 4-column press, with the spinning rollers between two columns, the work being spun on a vertical axis.
—EJT

Metrics?

To the Editor:

In practice, I do not see why a "conversion" (*PE—Oct* 2 '61, *p* 68) could not be effected by putting some summer student or apprentice draftsman to the job of writing metric dimensions over or under the present British ones. This could be done gradually; even if it took three months to thus "convert" currently used drawings, the extra time spent would be immaterial. Having done it in many instances, I should know.

From there on it takes a little engineering judgment to eliminate fractional millimeters, except in miniaturized designs which are largely metric anyway. Patterns can usually stand the changeover without immediate modification, and when new

ones are made, dimensions can easily be rounded off.

Then, if schools were progressive (meaning progressive in the non-political sense) enough to have their students work design in metric dimensions, and if American magazines were cooperative enough to give dimensions in both the old and the modern system (as some British magazines have done for decades) the transition would be quite painless.

As far as machine shops are concerned, a changeover would make absolutely no difference, as you yourselves prove. US machines are in use in Europe, and vice-versa, and that has to my knowledge never yet bothered an intelligent machinist. They seem to have less trouble that way than the professors have.

—MAX F WULFINGHOFF
Erlanger, Kentucky

COMING EVENTS

DECEMBER

12-14 . . . . Institute of Radio Engineers, AIEE, ACM, Eastern Joint Computer Conference, Sheraton Park Hotel, Washington

JANUARY

8-12 . . . . Society of Automotive Engineers, Automotive Congress & Exposition, Cobo Hall, Detroit

9-11 . . . . Institute of Radio Engineers, 8th National Symposium on Reliability & Quality Control, Statler-Hilton Hotel, Washington

24-26 . . . . American Society of Mechanical Engineers, 2nd Symposium on Thermo-physical Properties, Princeton Univ, Princeton, NJ

25-26 . . . . Univ of Wisconsin, Research Management Conf, Madison Campus, Madison Wisc

28-Feb 2 . . . . American Institute of Electrical Engineers. Winter General Meeting. Statler-Hilton Hotel, New York City

29-Feb 1 . . . . American Society Heating, Ventilating, Air Conditioning Engineers, Semi-annual meeting, Chase Park Plaza Hotel, St. Louis

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.

DRAFTING TRENDS

New, improved Rotolite Expeediter conveniently makes sepia reproducibles and diazo films in addition to low cost whiteprints.

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Here's a new, fast, economy whiteprinter that fills a real need in small drafting rooms or large engineering departments.

Workprints for architects, consulting engineers, surveyors, contractors. The Rotolite Expeediter can handle *all* copying needs for the two- or three-man drafting operation, is always ready to cope with rush jobs, even after hours. With POST Super Vapo Papers, print production can be doubled.

Quick checkprints for larger manufacturers. Even huge engineering divisions with their own reproduction departments praise Expeediter's practical, on-the-spot convenience for quick copies of preliminary sketches, checkprints, conference data, visual presentations. Hundreds of companies have placed Rotolites in their engineering and drafting rooms for "self-service" whiteprints in a hurry.

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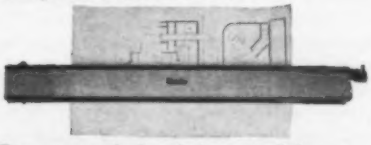

Recommended print materials. Use POST diazotype sensitized products—Vapo paper, sepia vellum, cloth or film—for best results. Get full information on Expeediter and standard Rotolite whiteprinters from your POST dealer or write Frederick Post Co., 3642 N. Avondale Ave., Chicago 18, Ill.

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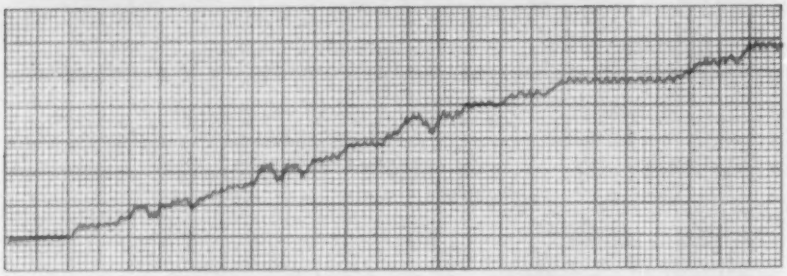
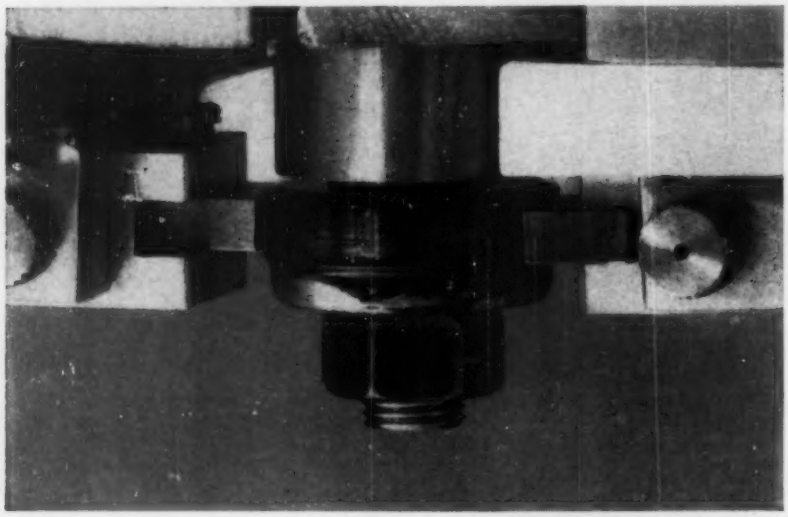
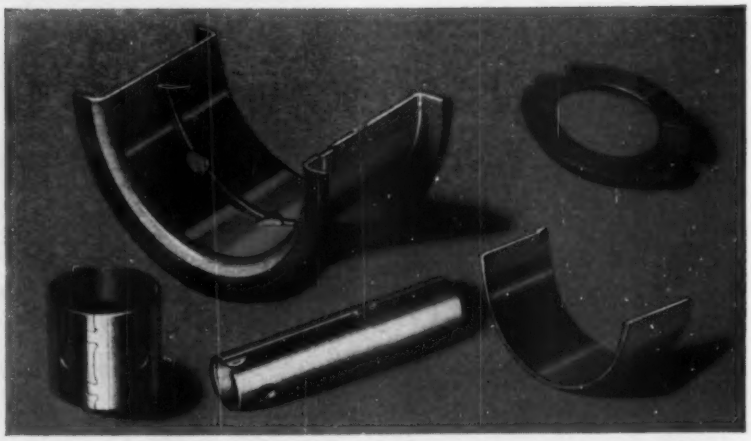
WE TAKE THE PULSE OF BEARINGS ON TAPE TO MAKE THEM EVEN BETTER!





TO TAPE-RECORD THE "HEARTBEAT" OF BEARING METALS UNDER LOAD, WE USE THIS SPECIAL FRICTION AND WEAR TESTER. (left) The result is highly accurate data on the behavior of bearing-metal surfaces, invaluable in our fundamental research into friction. By means of this instrument, we're able to correlate, more closely than ever before, specific alloy compositions with their degree of the "stick-slip" phenomenon (in which one surface sliding over another slides . . . stops . . . slides . . . stops . . . and so on) which accompanies unlubricated sliding action. We can also determine accurately the compatibility of bearing materials with shaft metals in lubricated systems . . . showing us which metal or alloy is most likely to be superior for a given bearing application. In short, this Friction Tester is a fundamental research tool which gives us positive answers to difficult bearing problems, faster than ever before.

ONE REASON WHY F-M SLEEVE BEARINGS and other F-M products give you the finest possible performance — this and the other unusual precision equipment used by Federal-Mogul research. You'll find F-M sleeve bearings used in turbines, engines, and countless other types of power transmission equipment . . . F-M precision thrust washers in pumps, automotive engines and transmissions, motors . . . F-M formed bushings in refrigeration compressors, electric motors . . . and low-cost F-M spacers in motor mounts, machinery, control mechanisms. These are just a few examples.



There's much valuable data in our Design Guides on sleeve bearings, thrust washers, and bushings; and in our brochure on spacers. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11043 Shoemaker, Detroit 13, Michigan.

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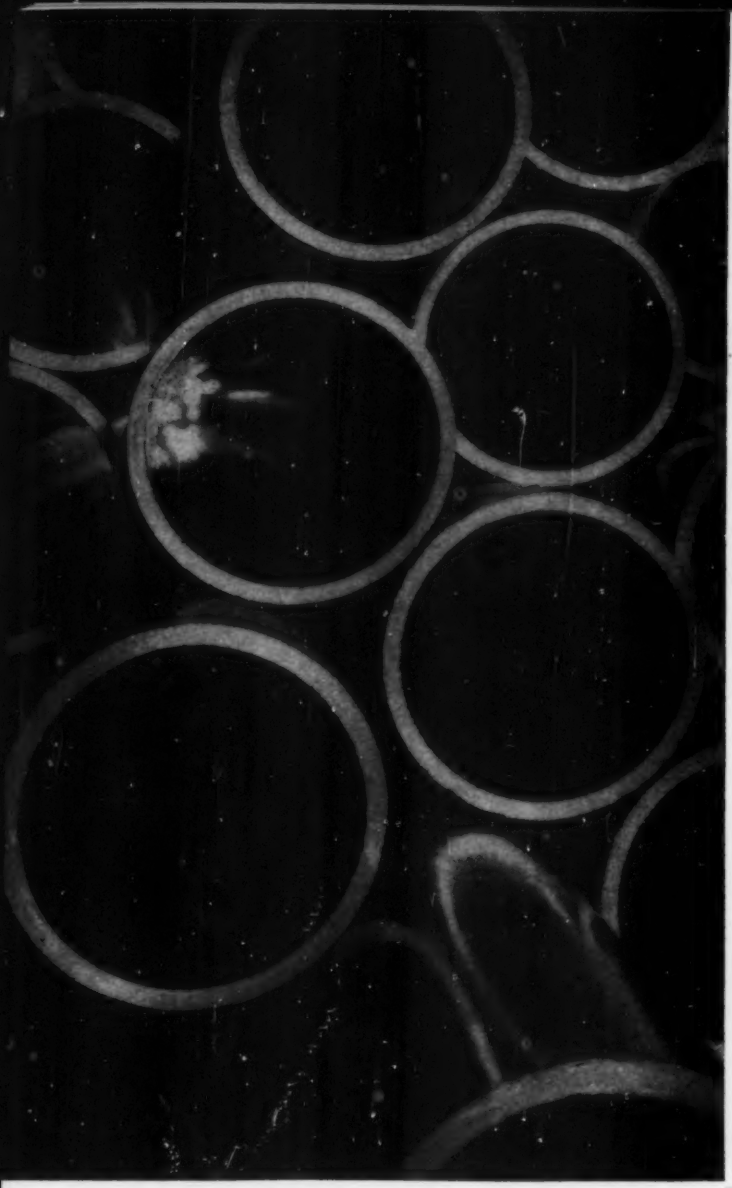
sleeve bearings · bushings · spacers · thrust washers

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.



This mark tells you a product is made of modern, dependable Steel.

Smooth . . . inside, outside . . . and accurate, too!

For a very fundamental reason, more and more Engineers, Designers and Purchasing Agents are specifying USS National Electric Resistance Welded Steel Mechanical Tubing—it saves money.

Dimensional accuracy and closely controlled mechanical properties insure consistency—consistently low machining losses, uniform strength, low fabrication costs and high torsion resistance—and the tubing is smooth inside and outside.

Whether your tubing application requires the dependability for a load-carrying member or the surface smoothness quality for a hydraulic cylinder, USS National Electric Welded Mechanical Tubing must be your first consideration.

USS National Electric Welded Mechanical Steel Tubing is available in a wide range of cold drawn or hot rolled sizes from as small as $\frac{3}{8}$" x .028" to as large as $5\frac{1}{2}$" x .250". Your National Tube Distributors throughout the country will gladly show you how tubing can reduce your costs. See your USS National Tube Distributor.

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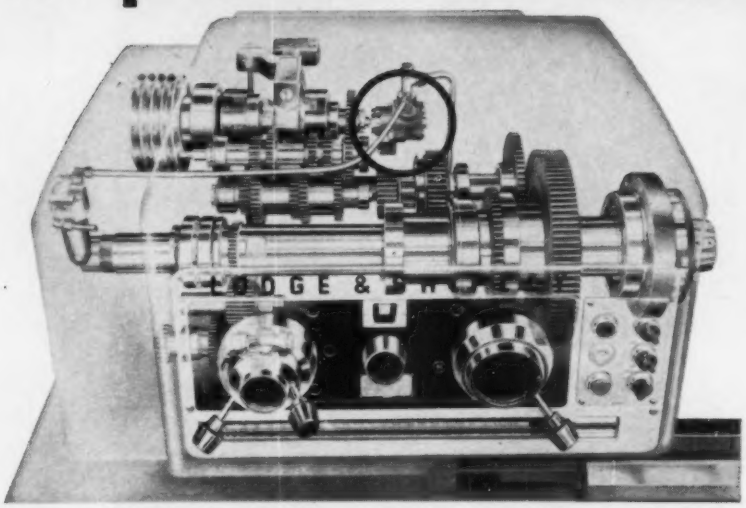
CIRCLE 17 ON READER SERVICE CARD

How to select or design a pump for pressure lubrication

by E. H. Schanzlin
Chief Engineer, Tuthill Pump Company

Our headline is something of a misnomer . . . for designing a pump for pressure lubrication today would be as pointless as designing a dowel pin.

Instead, there's a simple and increasingly popular answer to this problem. Practically every important manufacturer of air conditioning or large air compressors . . . manufacturers of machine tools . . . diesel engines . . . plus hundreds of manufacturers of diversified industrial equipment from valve operators to giant gear boxes . . . have selected Tuthill internal gear pumps for this demanding application because of compact size, economical price, quiet operation . . . and, above all, for their dependability, proven in over thirty years of operation.



Tuthill model ORL pump provides pressure lubrication for Lodge & Shipley POWERTURN lathes. Mounted in headstock area, this reversing pump is driven by a reversing clutch shaft, provides positive reversing action. Ports remain constant without use of valves.

Internal Gear Operating Principles

Tuthill internal gear pumps have only two moving parts. The pumping principle is based on the use of a rotor, idler gear, and a crescent shaped partition cast integral with the cover.

Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the inside diameter of the rotor is sealed by the crescent.

As the pump starts, the teeth come out of mesh increasing the volume. This creates a vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and the rotor, and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side, the liquid is forced from the spaces and out through the discharge port.

Special Advantages of Reversing Pumps

Tuthill also offers a complete selection (375 models) of internal gear pumps with a special reversing feature. The unique construction of these units permits positive reversing action without the use of valves, and with the port positions remaining constant.

Reversing pumps are necessary when the lubrication pump must be driven by a reversing shaft, or when machinery must be shipped without knowing the ultimate direction of the driving unit.

A good example is shown above. A reversing pump is mounted directly on the reversing clutch shaft in the headstock area of Lodge & Shipley's POWERTURN lathes to provide dependable pressure lubrication of these outstanding machine tools.

Stripped or Cartridge Models

For extremely crowded applications, or extra economy, Tuthill also offers a complete selection of stripped and cartridge models, in which only the basic pumping elements are supplied for incorporation directly into your equipment. These units have been widely used to supply positive pressure lubrication and hydraulic power in many important applications.

Over 800 Models

Tuthill's complete selection of internal gear pumps includes over 800 different models from stock for capacities from ⅓ to 200 gpm; for pressures to 500 psi; and speeds to 3600 rpm. Specially designed housings, shaft extensions, relief valves and many other features can be developed by Tuthill engineers for specific applications.

Write for complete catalogue No. 100 . . . or send us drawings on your application so Tuthill's engineers can make specific suggestions.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE
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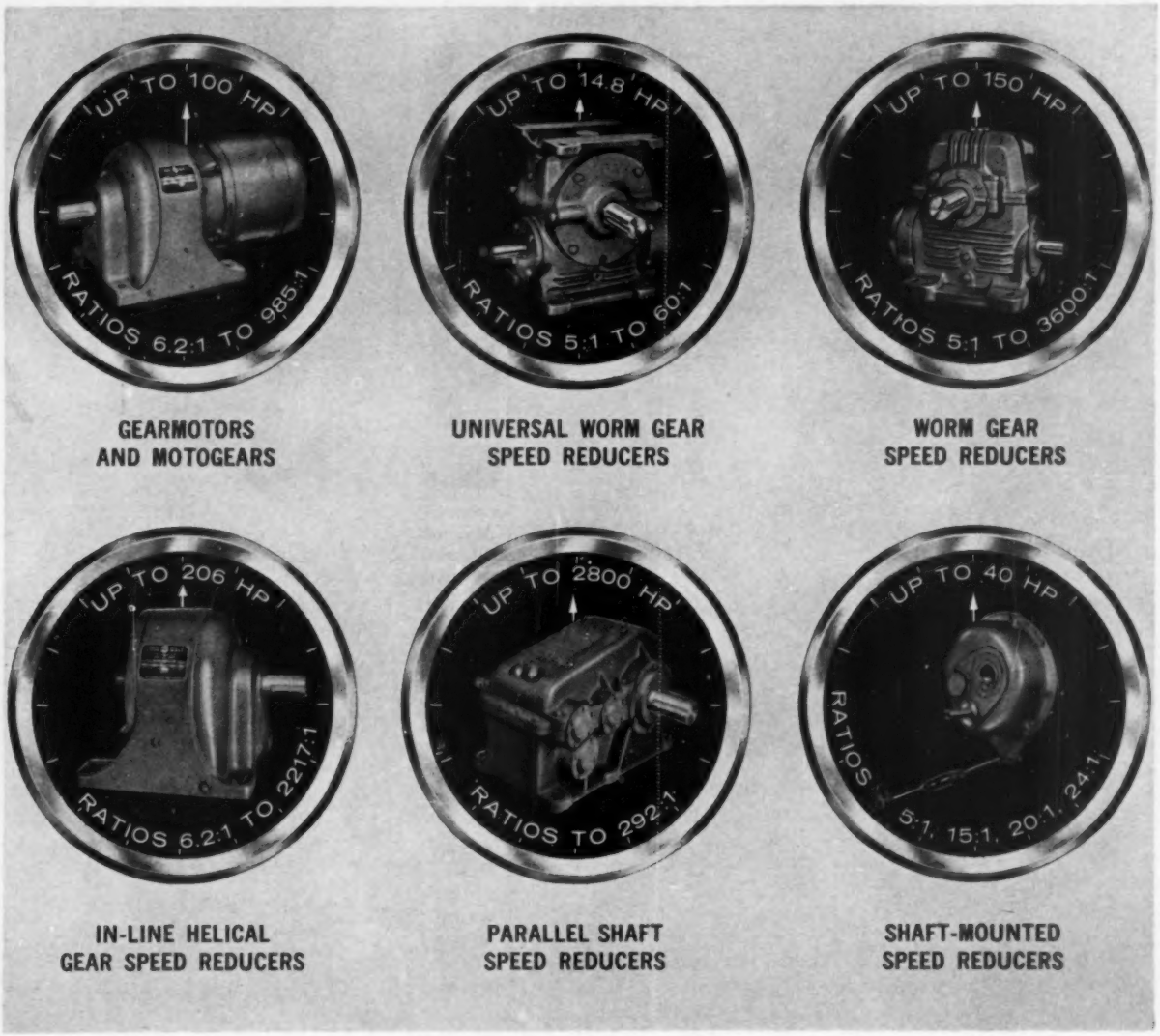
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RATIOS 5:1 TO 3600:1
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UP TO 206 HP
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IN-LINE HELICAL GEAR SPEED REDUCERS
UP TO 2800 HP
RATIOS TO 292:1
PARALLEL SHAFT SPEED REDUCERS
UP TO 40 HP
RATIOS 5:1, 15:1, 20:1, 24:1
SHAFT-MOUNTED SPEED REDUCERS

industry's most comprehensive speed reducer line!

WITH Link-Belt's broad line to choose from, you can plan *any* speed reduction setup . . . exactly meet your requirements for ratio, space, shaft position, shock loading and other service factors. Link-Belt's seven basic types of speed reducers—each in a wide range of sizes and ratios—give you complete flexibility in drive layout.

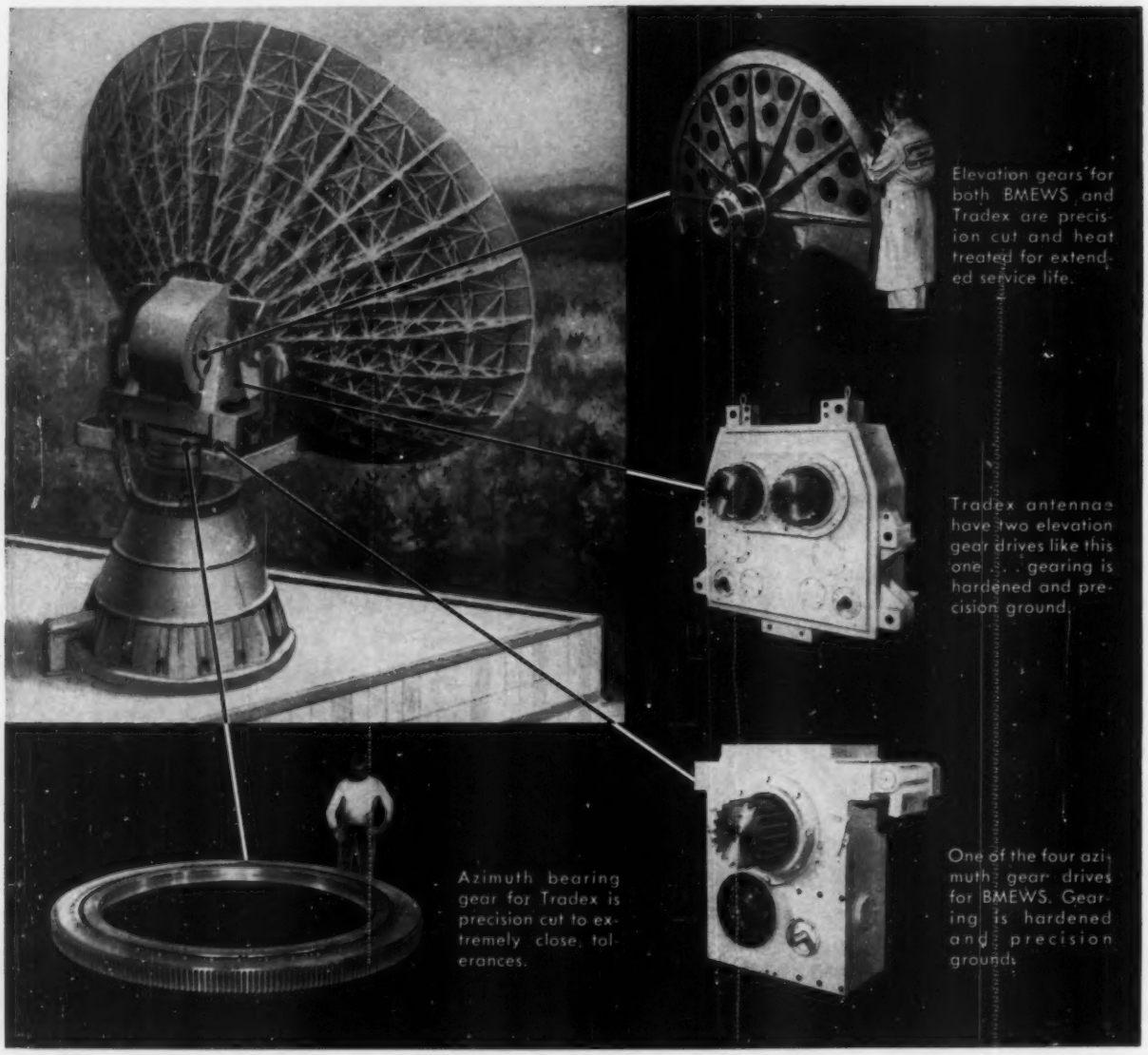
There's another important advantage in calling on Link-Belt for your speed reduction needs. Link-Belt makes all related drive components—chains and sprockets, bearings, couplings—all dimensionally correlated with these reducers. This one-source service assures you of a smooth-working, perfectly matched set of equipment. No alignment problems . . . no need to exchange drawings with other suppliers.

See the Yellow Pages for your nearest Link-Belt office. Look under "Speed Reducers." Ask for catalogs on any or all of the speed reducers shown above.

LINK-BELT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in all Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,703

PHILADELPHIA GEARS AND DRIVES power BMEWS and TRADEX antennae


Elevation gears for both BMEWS and Tradex are precision cut and heat treated for extended service life.
Tradex antennae have two elevation gear drives like this one . . . gearing is hardened and precision ground.
Azimuth bearing gear for Tradex is precision cut to extremely close tolerances.
One of the four azimuth gear drives for BMEWS. Gearing is hardened and precision ground.

When the giant radar tracking antennae for our ballistic missile early warning systems zero in on a 16,000 mph missile . . . and then hold it in dead center focus . . . there can be little margin for error.

The delicately sensitive, ultra precision movement of most of these big scanning dishes depends upon Philadelphia gearing and gear boxes.

Azimuth and elevation gearing is precision cut to extremely close tolerances. For installations involving severe loading cycles, the gearing is induction hardened to assure dependable long life and to maintain accuracy of teeth over an extended life period.

Rugged gear boxes are proportioned to critical stiffness requirements and gearing is precision ground throughout to assure minimum backlash and uniformity of performance from box to box. An added benefit is assured reliability over designed life expectancy.

Need a better solution to your gear and drive problems? Then write for our catalog, "An Advanced Concept in Modern Gears".

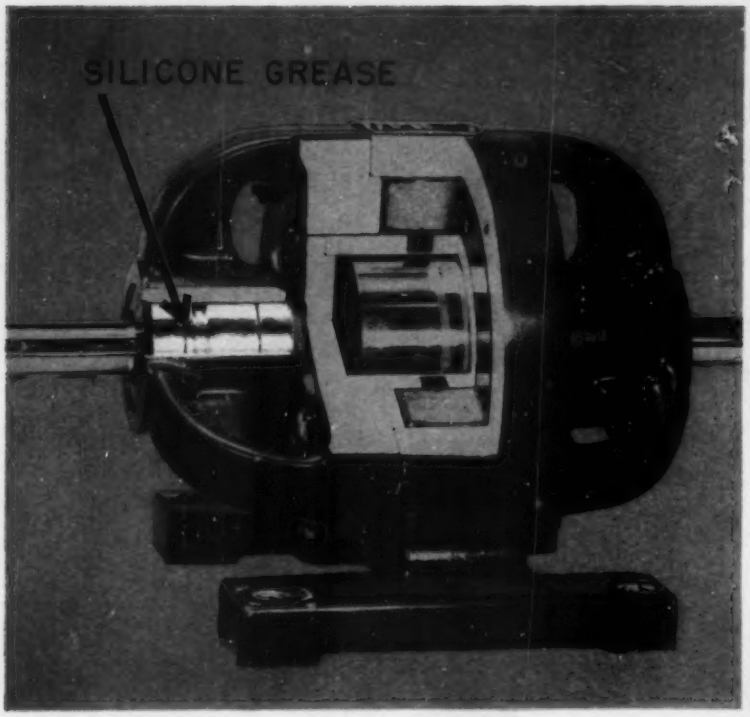
PHILADELPHIA GEAR DRIVES

PHILADELPHIA GEAR CORPORATION • King of Prussia (Suburban Philadelphia), Pa.

AGMA MEMBER

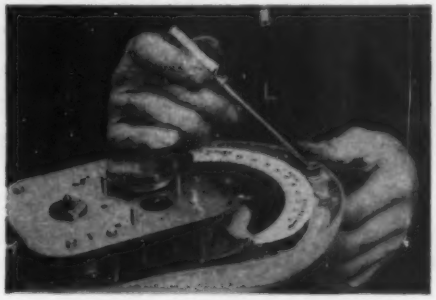
SILICONE NEWS from Dow Corning

Lubricants That Last



LONG SHELF LIFE—Lubricated with silicones, timing devices, made by Appliance Manufacturing Co., for automatic dryers, operate accurately and quietly after extended storage.

HEAT & COLD—Silicone lubricants prevent locks on parking meters from freezing up . . . eliminate lubrication problems.

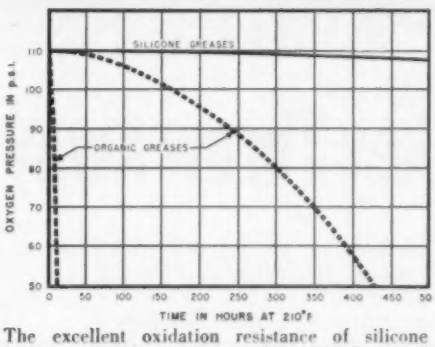


Silicone Lubricants Beat the Heat... Won't Oxidize In Service or On Shelf

Typical of the new designs made trouble-free with the aid of heat-stable Dow Corning Silicones is the magnetic clutch shown above. Manufactured by Vickers Incorporated, Electric Products Division, Sperry Rand Corp., St. Louis, Mo., this clutch can slip continuously, and therefore, must dissipate heat . . . heat that is conducted to the ball bearings. To lubricate these bearings, Dow Corning silicone grease was specified because it doesn't thin out and run away when temperatures skyrocket. Nonoxidizing, silicone grease remains operable for many years despite continuous temperatures of 450 F and higher.

YEAR 'ROUND LUBRICATION . . . INDOORS AND OUT. Silicone lubricants withstand both cold and heat . . . give all-year lubricity to outdoor mechanisms such as parking meters. Viscosity of silicones remains virtually constant down to —100 F . . . won't stiffen. Silicone lubricants also provide excellent shelf life, thus assuring instant starts for equipment left in storage for extended periods.

If your special design encounters any of the conditions just mentioned—high heat, cold, extended shelf life, weathering — a Dow Corning silicone grease will probably end your lubricating problems on metal, plastic or rubber parts. Send for literature, or outline your lubrication problem on your letterhead and we'll send you a free sample. Be your own judge. Address Dept. 5224a today.



The excellent oxidation resistance of silicone lubricants is shown above. After 500 hours of exposure to oxygen under 110 psi at 210 F, with a brass catalyst, silicone lubricants caused a pressure drop of only 1.5 pounds.

The nearest Dow Corning office is your number one source for information and technical service on silicones.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

CIRCLE 21 ON READER SERVICE CARD 21

Standard Forge & Axle Co. forges 5-inch by ½-inch Pittsburgh Seamless Mechanical Tube ends down to 2⅝" solid steel wheel spindle ends (cross section above). The Montgomery, Ala., plant then machines and grinds bearing surfaces to .0005-inch tolerance to produce single-piece, 20,000 pound capacity trailer axles. Trailer operators benefit from higher payloads because . . .

They Throw Away The Holes—And Save Weight

The trick in making a seamless steel tube is piercing a hole in a round of solid steel.

But Pittsburgh Steel Company's Seamless Steel Mechanical Tubing makes the full circle in production of trailer axles at Standard Forge & Axle Co., Montgomery, Ala.

Standard, in effect, throws away the holes by forging the tube ends down to solid steel again, leaving only a hollow steel center and spindle section.

The result: a lightweight, one-piece trailer axle made entirely from a single length of seamless tube—including load bearing wheel spindles, precision ground for bearing and seal seats.

The advantage: assured strength and safety of seamless steel, plus, for example, reduced axle weight for trailer operators in a 20,000 pound capacity axle.

Starting with a seamless steel tube 5" x ½" x 87⅛" for this particular axle, Standard upsets both ends, then swages them down to the shape of a spindle with a 2⅝" solid end.

That's deformation of the roughest kind.

But Pittsburgh Seamless Mechanical Tubing takes it in stride, then bounces back under heat treatment with the physical properties required for precision finishing of the critical spindle surfaces, and the toughness necessary for a long life in hard service.

And that kind of performance takes seamless steel tubes with exceptional internal soundness, consistent grain structure, and chemical and dimensional uniformity.

Pittsburgh C-1040 grade Seamless Mechanical Tubing supplies these properties consistently—for this type

After upset, Pittsburgh Seamless Mechanical Tubes, with 5-inch OD and ½-inch wall, are swaged to solid steel spindle shape on drop forge, at right. Standard's heat treating process refines grain, restores toughness of steel.

Standard also produces high-strength inserted spindle trailer axle by inserting forged alloy steel spindle with 4.065-inch OD into 4.040-inch burnished ID of 5-inch seamless steel tube under 50,000-pounds pressure.

Standard Forge & Axle Sales Manager James A. Rumbley says Pittsburgh Steel Company, as longtime major supplier of seamless mechanical tubes, "leaves nothing to be desired in product or service."

axle and for Standard's high-strength inserted spindle type.

James A. Rumbley, Standard's sales manager, says:

"Trailer axles are high-weight carrying members subject to tremendous load shocks. So we use the finest materials available to assure our customers trouble-free service. Seamless steel mechanical tubes help us to do that, with complete safety and at less weight.

"For many years, Pittsburgh Steel Company has been one of our major tubing suppliers. It has left nothing to be desired either in product or service."

That's standard practice with Pittsburgh Steel—whether supplying seamless mechanical tubing to Standard's specific requirements, or to yours. Be certain with Pittsburgh Seamless. Contact one of the district offices listed below.

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

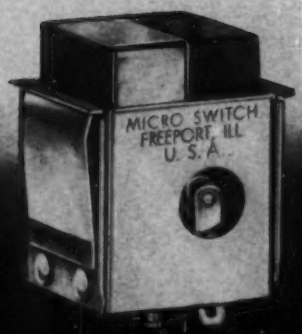
DISTRICT SALES OFFICES

Atlanta	Cleveland	Dayton	Los Angeles	Pittsburgh
Chicago	Dallas	Detroit	New York	Tulsa
		Houston	Philadelphia	Warren, Ohio

Steel

CIRCLE 23 ON READER SERVICE CARD 23

MICRO SWITCH Precision Switches



NEW! ALTERNATE ACTION LIGHTED PUSHBUTTON

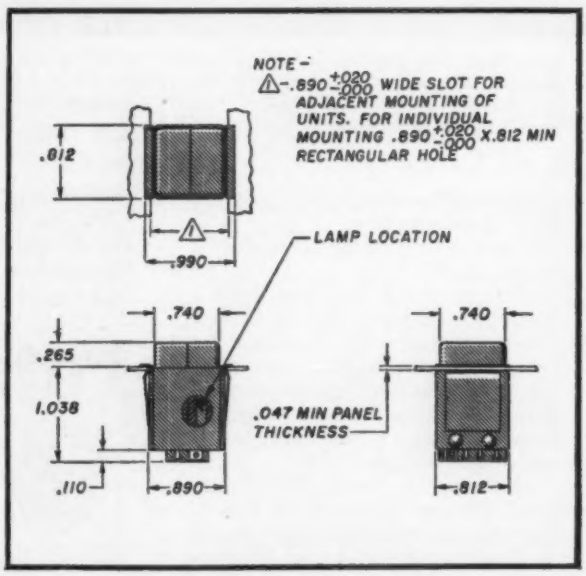
Reliable snap-action switches

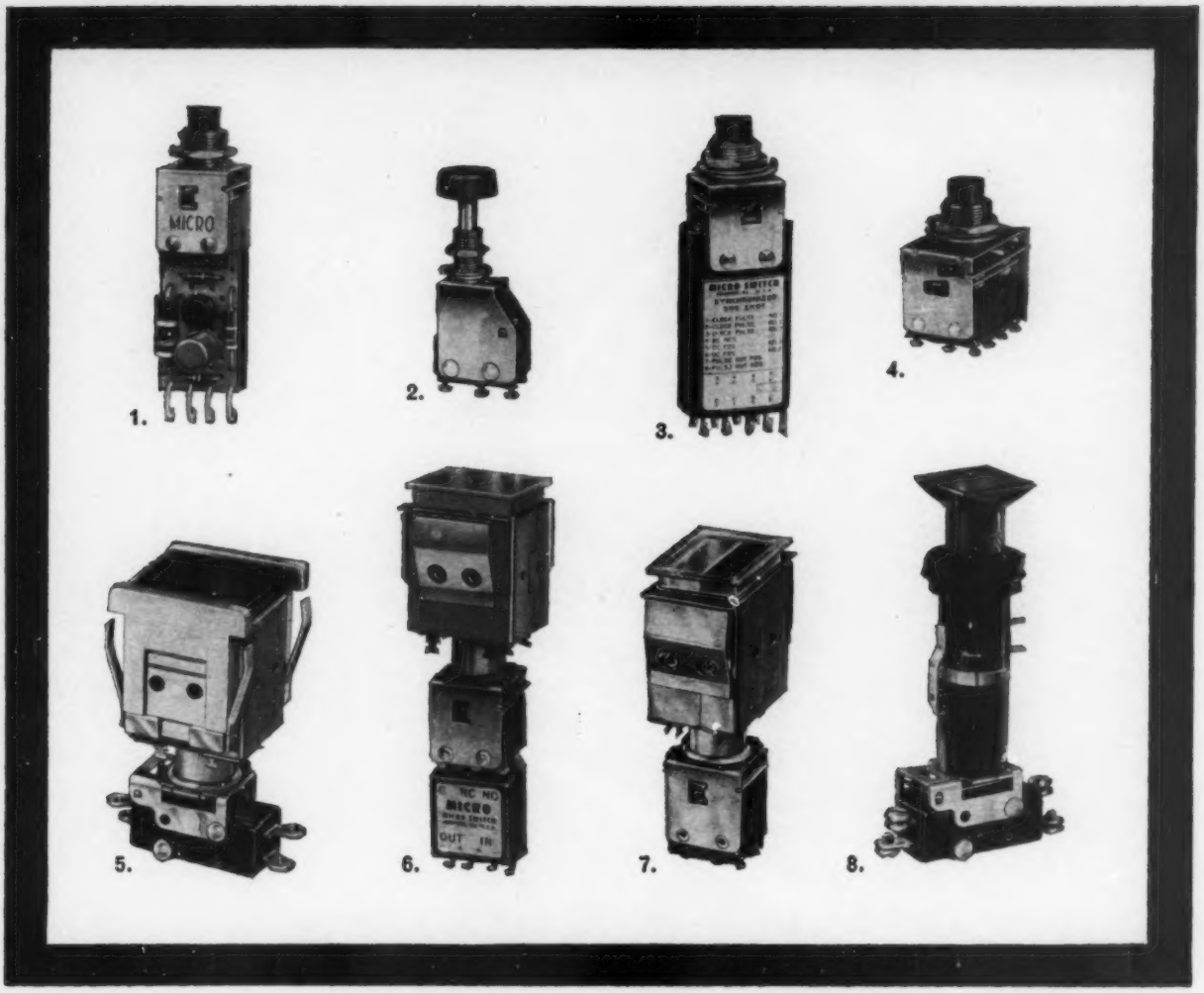
Here is a new concept in ultra-small lighted pushbutton switches for control with integral simultaneous visual indication. Switches in the "300" series are designed for military and industrial electronic control panels where space is an important factor.

In less than one cubic inch: double-pole double-throw switching; two integral lamps; choice of 15 combinations of two-color display screens. Alternate-action operation (push on—push off). Designed to conform to MIL-S-6743, MIL-S-6744, and MIL-E-5272.

Within the assembly are two SPDT switches, rated 7 amps. 115-230 vac or 28 vdc. A 5-volt sub-miniature lamp is under each half of display screen and there are 15 combinations of color display available. The complete unit snaps into panels 0.047 in. thick or greater. No installation tools needed. Minimum mechanical life is 100,000 operations. Lamp life is 60,000 hours at rated load.

Available in the same size are a momentary-action switch, and an indicator unit without switching function.





for electronic control panels

CUSTOM-BUILT CONTROL PANELS REQUIRE CAREFUL SELECTION OF SWITCHES

Immediately available are hundreds of small size switch units with variations in dimension, electrical capacity, shape, appearance and circuitry. All have undergone thorough tests in the most complete test laboratory of its kind.

Shown above and briefly described here are only a few of the hundreds of types of switch assemblies available.

1. Electronic switch-circuit for bounce-free voltage output.
2. Light force, rapid repeat pushbutton.
3. Synchronized "one-shot" pulse circuit.
4. Compact, 4-pole snap-action pushbutton.
5. Lighted pushbutton, modular design, barrier mount.
6. Lighted pushbutton, electronic "one-shot" switch-circuit.
7. Two-color lighted pushbutton, snap-in flange mounting.
8. Bushing mount lighted pushbutton, high capacity, 2-ckt switch.

For more information and for experienced help in selection, contact one of our many branch offices listed in the Yellow Pages, or write for Catalog 67 and Bulletin 22.

MICRO SWITCH, FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

CIRCLE 25 ON READER SERVICE CARD 25

Tough, durable Mylar® cuts costs... improves product performance

For example, "Mylar"* polyester film's high tensile strength in thin gauges helps make products lighter, less bulky. Yet they last longer. Right now, "Mylar" with its resistance to heat, cold, chemicals and moisture is improving the performance of products as different as lustrous metallic yarns and tough, flexible exchange cable.

Can this unique plastic film and products made with it help you? For more information on "Mylar", write: Du Pont Co., Film Dept., Room #8, Wilmington 98, Del.

1. Pressure-sensitive tape of "Mylar" is thinner, stronger. Resists tearing and corrosive chemicals and moisture.

2. Metallic yarns of "Mylar" stay sparkling through dyeing, washings and wearings, even in sun and salt water.

3. Volatile corrosion-inhibitor packages of "Mylar" fight rust, offer easy identification of parts.

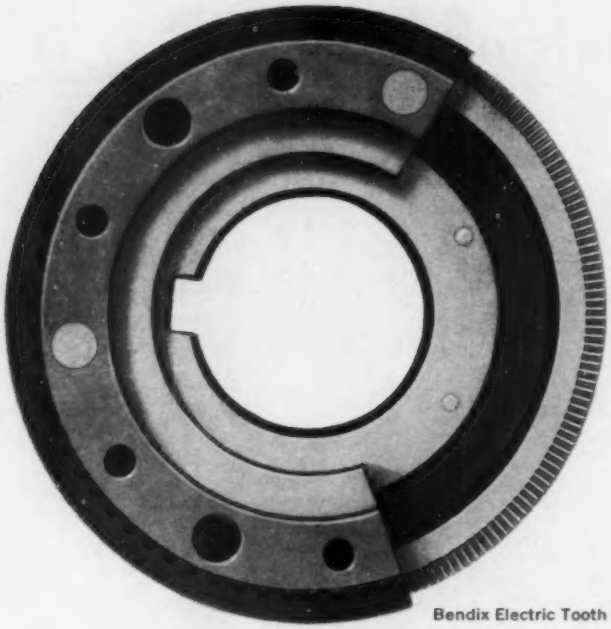
DU PONT

REG. U.S. PAT. OFF.

*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

Better Things for Better Living . . . *through Chemistry*

DU PONT MYLAR® POLYESTER FILM



Bendix Electric Tooth Clutch

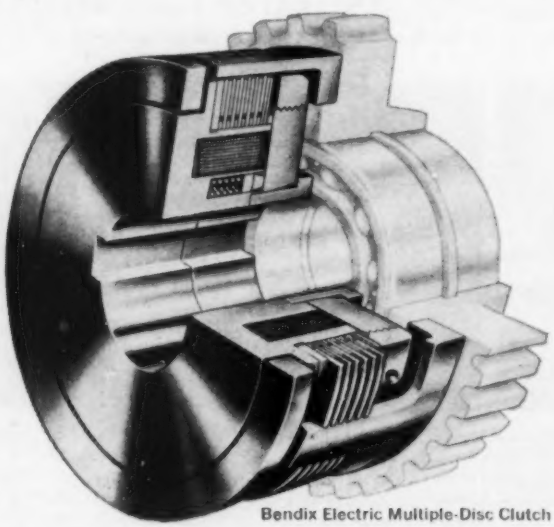
BENDIX ELECTRIC CLUTCHES PUT "PUNCH" IN MACHINE OPERATION

One good way to get the extra response it takes to outperform competition is to include Bendix® Electric Clutches in your machine designs. They engage and disengage faster, accelerate smoother, permit faster machine operation. Available in both tooth and multiple-disc types, they provide more positive clutching, more torque in less space. **Bendix Electric Tooth Clutch.** For positive, high-torque transmission; wet or dry applications. Lightweight, compact, has only 3 parts. Mounts easily; may be engaged at relative speeds. Disengagement possible under full load while running at maximum rpm. Available in torque capacities of 40 to 4,000 ft.-lbs. **Bendix Electric Multiple-Disc Clutch.** Provides precise control and quick response in high-frequency operations. There is no flux path through the magnetically isolated disc stack. Slip ring or stationary field design. Wet or dry applications. Want more facts? Write The Bendix Corporation, Eclipse Machine Division, Elmira, N. Y.

Export Sales and Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

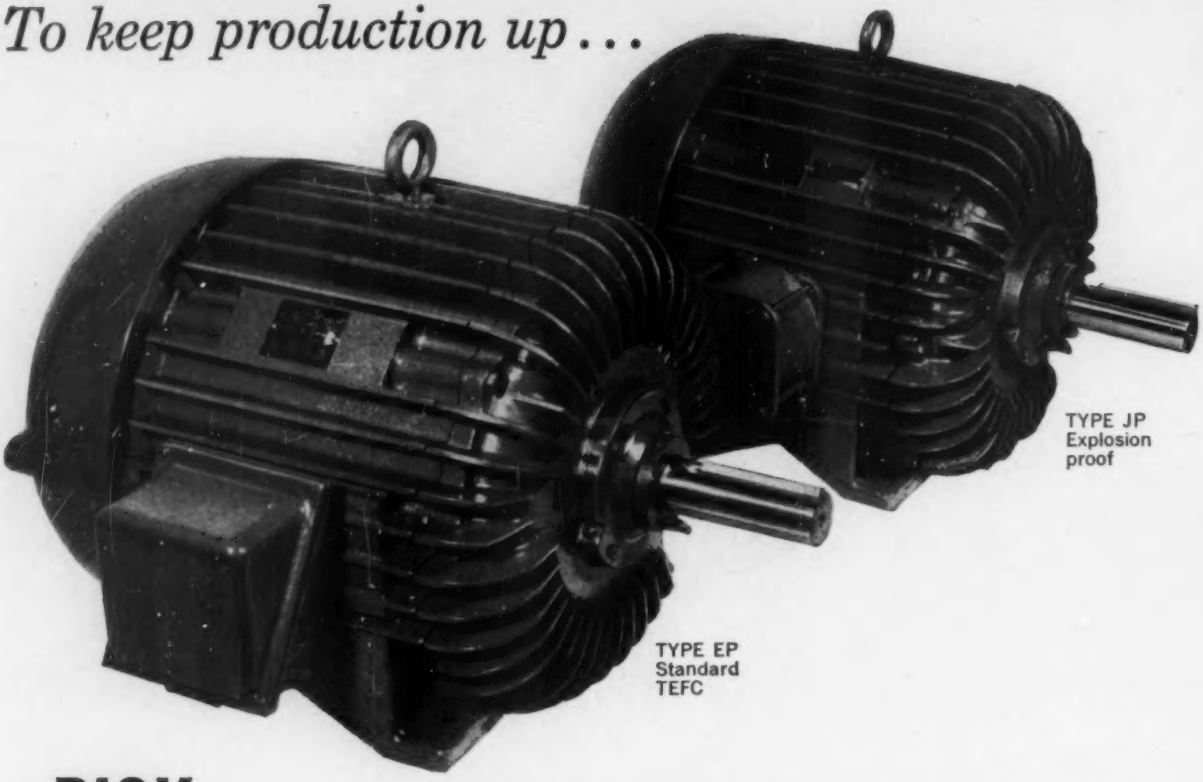
Bendix-Elmira

THE Bendix CORPORATION



Bendix Electric Multiple-Disc Clutch

To keep production up...



PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

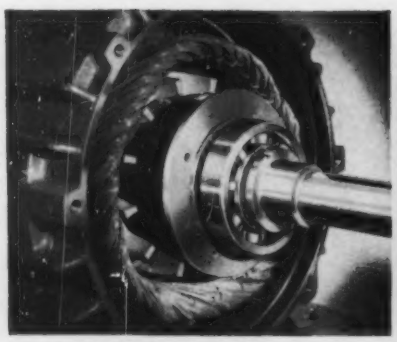
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

Wagner Electric Corporation

6406 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WM60-19



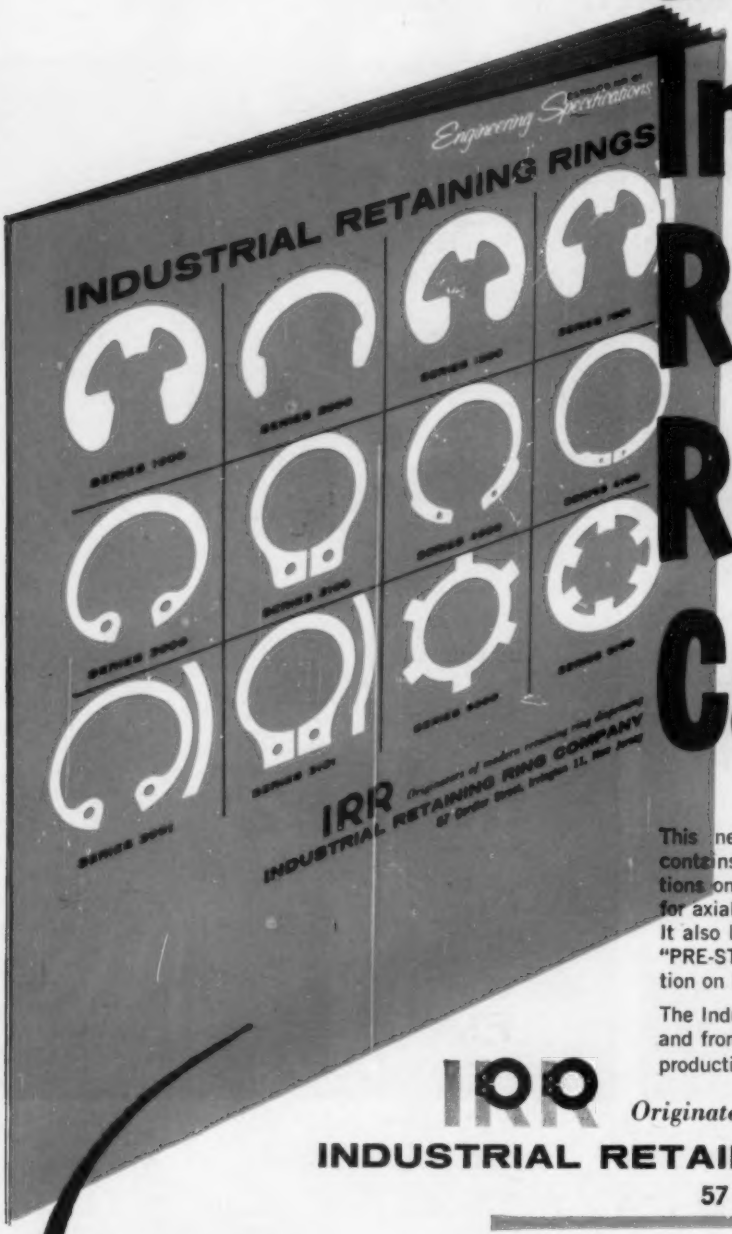
HEAVY-DUTY BALL BEARINGS... The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.

BEARINGS CAN BE RELUBRICATED... Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SECURELY SEALED FOR LOW MAINTENANCE... Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

For YOUR File . . .

New! Industrial Retaining Ring Catalog



This new Industrial Retaining Ring Catalog, No. 61, contains complete information and engineering specifications on IRR Internal and External Retaining Rings—both for axial and radial assembly—from sizes .040" to 4.125". It also has information of the exclusive, time-saving, IRR "PRE-STACKED" Axial Assembly Rings as well as information on IRR Pliers and Accessories.

The Industrial Retaining Ring Catalog is easy to work with and from. It will greatly assist in design, purchasing and production.

IRR *Originators of modern retaining ring dispensing*

INDUSTRIAL RETAINING RING COMPANY

57 Cordier Street, Irvington 11, New Jersey

Use for FREE Samples and Catalog

INDUSTRIAL RETAINING RING COMPANY
57 Cordier Street, Irvington 11, N. J.

Please, send me samples of Industrial Retaining Rings and the new IRR Catalog No. 61.

Name ..... Title .....

Company .....

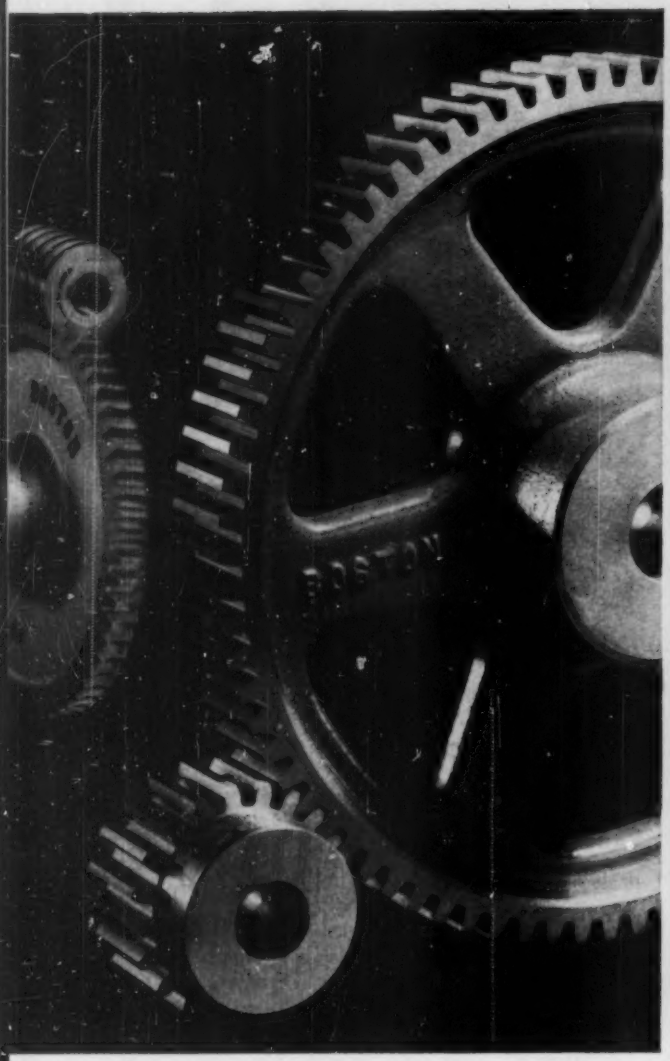
Street .....

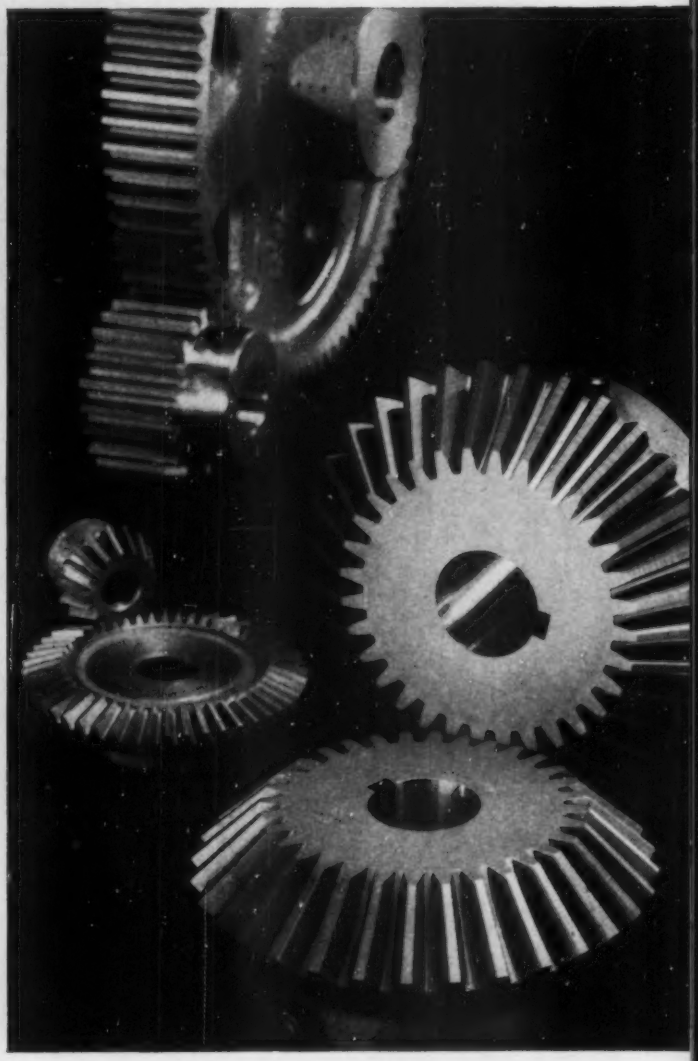
City ..... Zone ..... State .....

BOSTON Gear® QUALITY

largest selection . . . 14½° and 20° P.A.

standard stock gears





Off-the-shelf delivery – from local stock

1781 types and sizes 14½° P.A. – 48 to 3 pitch

782 types and sizes 20° P.A. – 120 to 4 pitch

Spur, bevel, miter, worm, helical, spiral miter, internal

Brass, steel, iron, nonmetallic. See Catalog 57.

IN STOCK at your nearby DISTRIBUTOR

BOSTON Gear®

CIRCLE 30 ON READER SERVICE CARD

© Boston Gear Works, 1961
Quincy 71, Mass.

ALLEN INTRODUCES

LOKON

NEW general-purpose LOCKNUT holds positively tight even after repeated on-off cycles . . . provides a "commercial" locknut in the "aircraft" quality range . . . offers strength without bulk for heavy-duty applications

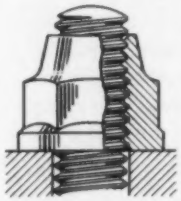
True to its name, the LOKON nut locks on a companion threaded member with a can't-shake-loose grip . . . holds indefinitely against heaviest impact and vibration. Because the basic design allows adequate deformation of the "turret top" without overstressing any portion of the periphery, "LOKONS" are highly resistant to fatigue failure. And, through closely controlled heat treatment, a degree of elasticity is achieved which permits re-use time after time without significant impairment of the locking action.

LOKON locknuts assemble fast and easy . . . start with finger spinning . . . tighten smoothly . . . lock at any point as soon as the threads in the elliptical section are fully engaged, and are readily removed without damage to the nut or mating part.

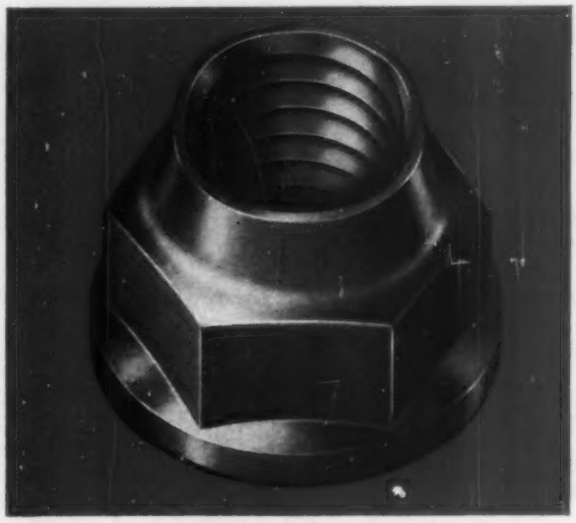
Investigate LOKON at the first opportunity. Discover the many ways this major development in locknuts can save you time and cut costs. Test samples* and engineering data are yours for the asking. And, for prompt, off-the-shelf delivery, call your nearby Allen Distributor who carries full stocks of LOKON locknuts as well as dependable Allen hex-socket screw products.

**Currently offered in sizes from No. 10 through ½", UNC and UNF threads. Other sizes available soon.*

HOW *LOKON* LOCKS . . .



The threads in the tapered crown of the nut are slightly distorted from the round. When assembled to a companion threaded member, this out-of-round condition causes the nut to resist free entry of the mating part. As the metal flexes in an effort to conform to the circular pattern of the male threads, friction on the flanks of the nut threads is increased. The compressive forces exerted as a result of this diaphragmatic flexing action produce a positive, powerful locking grip.



Only "LOKONS" offer all these extras . . . all without EXTRA COST!

ONE-PIECE, ALL-METAL CONSTRUCTION — The LOKON design requires no segments, inserts or other auxiliary locking devices.

HIGH-GRADE ALLOY STEEL — Heat treated to Rc 26/30. Imparts tensile strength in excess of 250,000 psi and provides lasting spring tension for unlimited re-usability.

CLASS 3B THREADS — Comply fully with specification MIL-S-7742 and H-28 Handbook.

BUILT-IN FLANGE — Large-area bearing surface saves washer cost, speeds assembly, reduces indentation. Face of flange is held square with threads to insure even distribution of stresses throughout the flange and thread area.

DIMENSIONAL ACCURACY — Allen "pressur-forming" processes control grain flow, hold tolerances to consistently close limits, and produce fully-formed hex corners for sure-grip wrenching.

HIGH TEMPERATURE SERVICE — Performance is unaffected at temperatures to 550°F.

MILITARY SPECIFICATIONS — LOKON locknuts fulfill the performance requirements of MIL-N-25027.

ALLEN HEAD **ALLEN**

THE ALLEN MANUFACTURING COMPANY • HARTFORD 1, CONN., U.S.A.
PLANT AT BLOOMFIELD, CONN. • WAREHOUSES IN CHICAGO, CLEVELAND, LOS ANGELES

INDUSTRIAL DISTRIBUTION — THE BEST RATED BY PURCHASE

FOR OVER 50 YEARS, MAKERS OF FAMOUS ALLEN SOCKET SCREW PRODUCTS

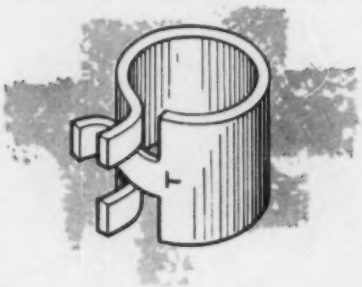
CIRCLE 31 ON READER SERVICE CARD

INFORMATIVE NOTES TO IMPROVE YOUR PRODUCT ...SAVE YOU MONEY

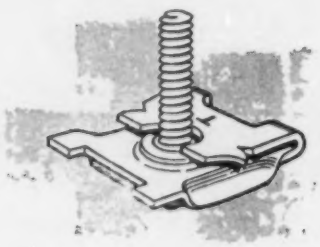
Published as a service to Designers and Engineers

Ideas from Tinnerman have cut costs, improved products. Here are examples from Tinnerman's 10,000 variations of SPEED NUT brand fasteners —all stamped with the T-mark of *total* reliability.

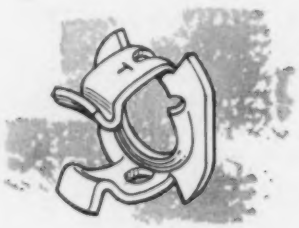
Tinnerman can help *you* cut costs with a free Fastening Analysis of your product. Call your Tinnerman representative, or write: *Tinnerman Products, Inc., Department 12, P. O. Box 6688, Cleveland 1, Ohio.*



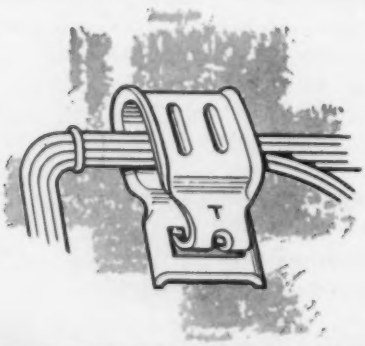
VERSATILE COMPRESSION RING has solved fastening problems in car radios, pressure gages, washers, and speaker cabinets. Simply squeeze compression fingers with pliers to expand . . . release, and spring tension maintains firm connection. Heat-treated spring steel of this SPEED CLIP® fastener won't lose tension, won't loosen under vibration. Possible applications are practically unlimited.



BOLT RETAINER used to fasten grille extensions to car fenders, has potential usage in any field where high-torque fastening is required on thin metal sections. This SPEED GRIP® fastener eliminates costly welding or staking, speeds assembly, allows savings in labor costs and parts handling. Barbs locate fasteners until nut is driven. One of Tinnerman's extensive line of SPEED GRIP nut and bolt retainers.



ELECTRONIC CONTROL CLIP retains tuning switch on chassis, gives constant spring tension for both push-pull and revolving controls . . . can be used wherever electronic controls are installed. This multipurpose SPEED CLIP fastener replaces threaded nuts, bushings, lockwashers. Cuts costs substantially. Live spring action lasts for the life of the equipment.



WIRE RETAINER is ideal for attaching single wire, light harness, cables or tubing. This SPEED CLIP fastener can be preassembled on the harness, allowing an entire wiring system to be snapped into place in seconds. Double embosses on upper clamping leg trap cold-flow tendencies of vinyl covered cord, assure 35 pound pull resistance. Clip will accept any wire or bundle up to .306" x .515".

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano Simmonds GMBH, Heidelberg.

TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

Plaques of tough Butyrate plastic give super-service at gas pumps

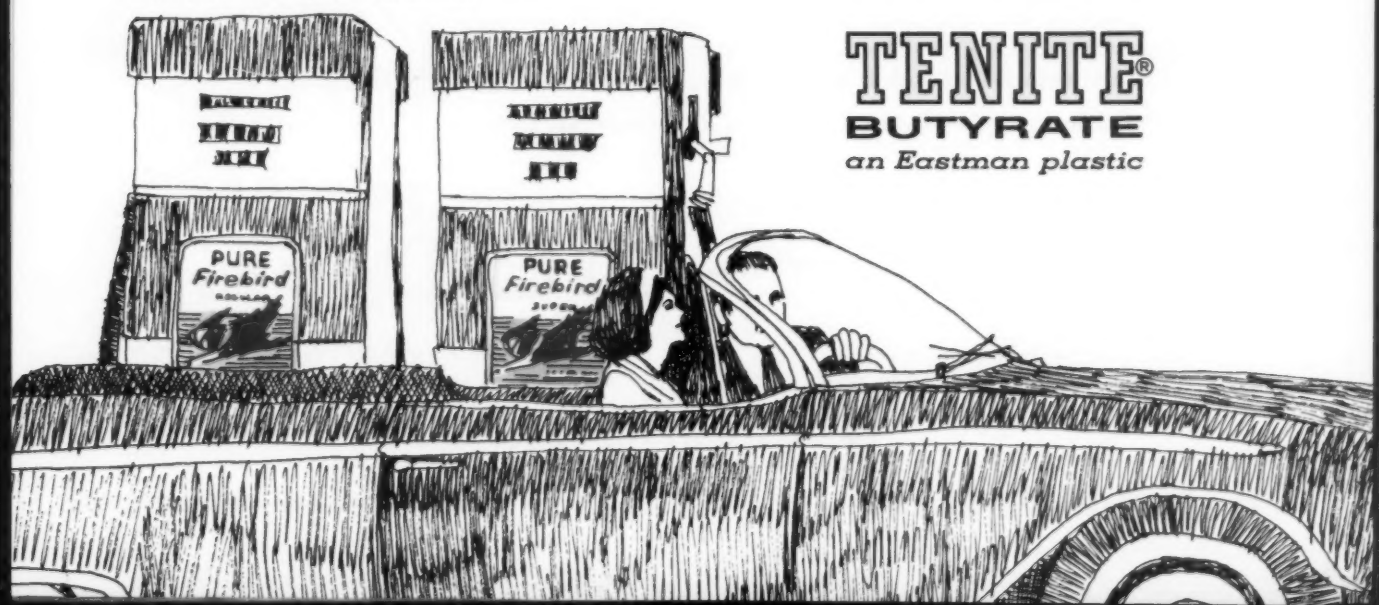
Toughness, weatherability, and eye-appeal are some of the reasons The Pure Oil Company chose sheet of Tenite Butyrate for these three-dimensional plaques. Mounted on 72,000 service station pumps, they build recognition for the new "Firebird" brand of gasoline.

And they'll stay bright and new-looking. The plastic sheet is extruded of a special outdoor formulation of Tenite Butyrate that endures weather and temperature changes, sunlight, wind, rain, snow, and hail, along with gasoline, oil, and air-borne dirt and grime. The inherent toughness and resilience of Butyrate sheet minimize breakage during manufacture, shipment, and installation, and throughout a long service life.

In producing the plaques, economies resulted from silk-screening the colors in distortion on the reverse side of clear-transparent Butyrate sheets. Subsequent vacuum-forming produced the three-dimensional plaques with striking legibility and excellent registration of the color patterns. The decoration is protected by the thickness of the clear Butyrate sheet and enhanced by its surface gloss.

If sheet of tough Tenite Butyrate plastic, in clear-transparent or tested outdoor colors, suggests ideas for improving your product, get more information and a list of suppliers from EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Plaques vacuum-formed by Dualite Products, Inc., Cincinnati 27, Ohio, from sheet of Tenite Butyrate extruded by General Plastics Corp., Marion, Indiana.



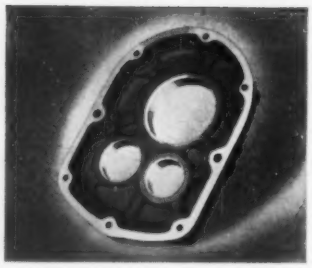
TENITE®
BUTYRATE
an Eastman plastic

...the quality-engineered package

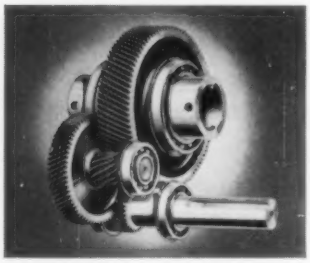
that simplifies speed reduction

DODGE TORQUE-ARM, America's most widely used shaft mounted speed reducer, will save money for *you.* No foundation, no sliding motor base, no flexible coupling, no installation fuss. Developed and perfected by Dodge, this reducer has been so widely accepted in industry that it is now built and stocked in this unmatched range of sizes and models: capacities up to 170 hp; output speeds from 10 to 400 rpm; ratios of 5:1, 15:1, 25:1; speed ratios up to 175 to 1 with correct selection of speed reducer and V-belt drive. Built-in backstop available. Also positive overload release. Vertical models. Flange mounted models. Special application models . . . Go modern—go Torque-Arm! See your Dodge Distributor, or write us.

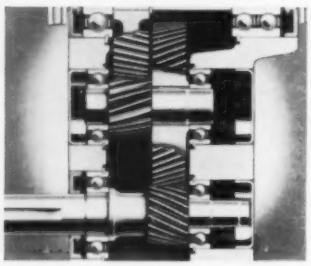
Dodge Manufacturing Corporation, 1200 Union St., Mishawaka, Ind.



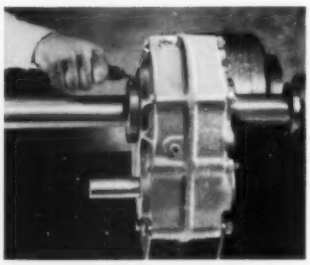
Rugged, semisteel housing holds bearing seats in line for entire life of unit. Laughs at loads. Corrosion resistant.



AGMA rated helical gears. Soft cores withstand shock; hardened surfaces defy wear. Teeth are crown shaved.



Gears are located *between* bearings and carry their loads without strain. Longer life, higher efficiency.

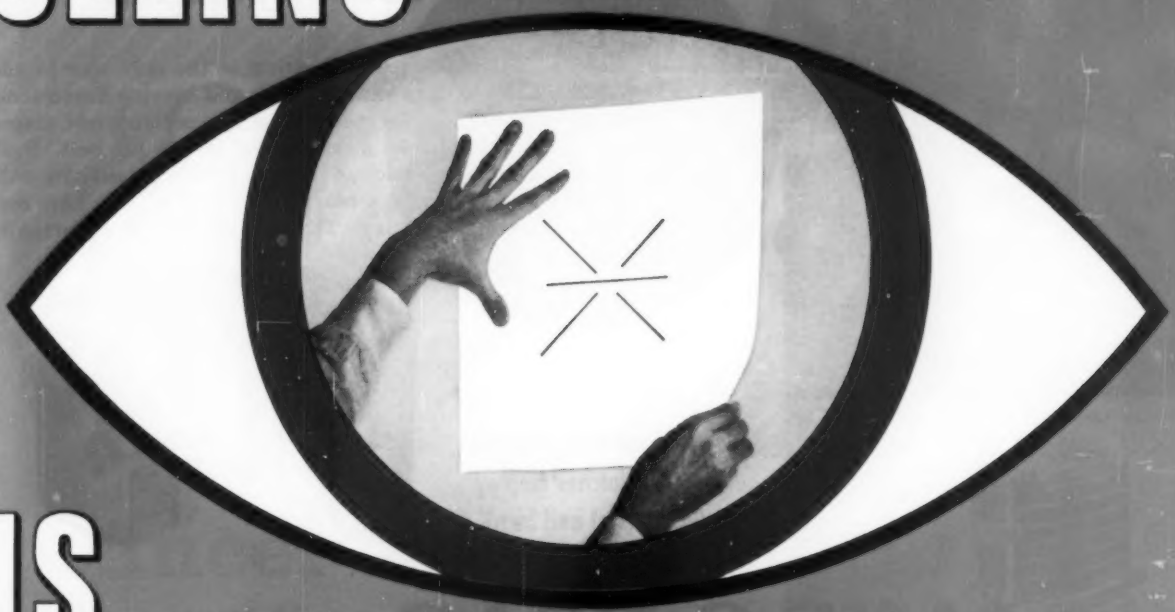


Unit slides completely onto shaft and locks on *both* sides of housing. This baby stays *put*—runs truer longer.

The Products with the Pluses... **DODGE** *of Mishawaka, Ind.*

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge he can give you valuable assistance on new cost-saving methods.

SEEING IS BELIEVING!



See for yourself why leading engineers and architects demand Clearprint Technical Papers. Ask for a sample, then make this convincing test:

1. **INVITES THE PENCIL**
   Try Clearprint's perfect working surface with a 2H pencil, then with a ruling pen. Lines are sharp and clean—no feathery edges.
2. **HIGHEST ERASING QUALITIES**
   NO GHOSTING – Erase some of the lines. Redraw and erase several of them time and again. Crease the paper, too. Then hold it to the light, or make cleanest possible reproductions.
3. **NEVER CHANGES**
   Sheets in use for 27 years prove Clearprint's amazing stability. Its strength, transparency and printing qualities remain unchanged after extended exposure to age, atmosphere, heat and light. ITS COLOR DOES NOT CHANGE.

If you are not using Clearprint now, please make this comparative test on the paper you are using.

to prove it's best make the Clearprint test

CLEARPRINT®

"FADE-OUT" PAPER T.M.
TECHNICAL PAPER
FORMS • CHARTS • GRAPHS
"PRE-PRINT" PAPER T.M.
THERE IS NO SUBSTITUTE
Clearprint is Watermarked For Your Protection

15

CLEARPRINT PAPER CO. PE-1560
1482 - 67th St., Emeryville, Calif.

☐ Send me Clearprint Fade-Out samples, with prices, for the following uses:_____

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City_____ Zone___ State_____

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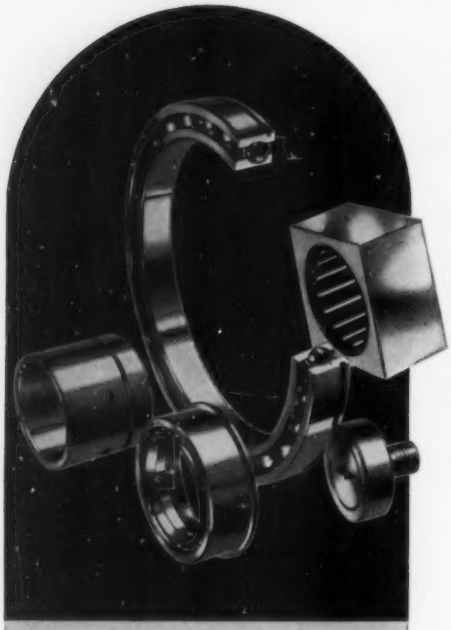
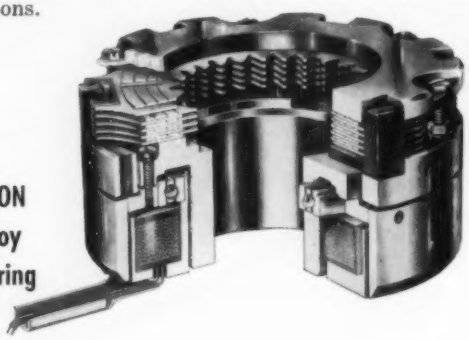


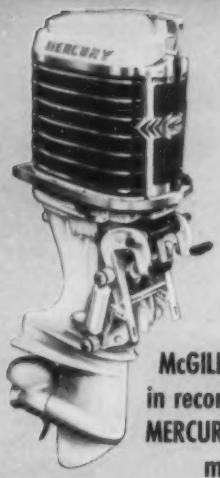
McGILL® can solve your special purpose bearing problems

You may have found that a special bearing is the only way to add anti-friction advantages to non-standard shaft and housing dimensional combinations—perhaps a special type bearing incorporating odd shaped components or adjacent machine members will do the job best. Such special bearing design and production is part of everyday activity with McGILL. So don't design around a bearing barrier until you have consulted McGILL creative engineering. They will welcome an opportunity to make recommendations.



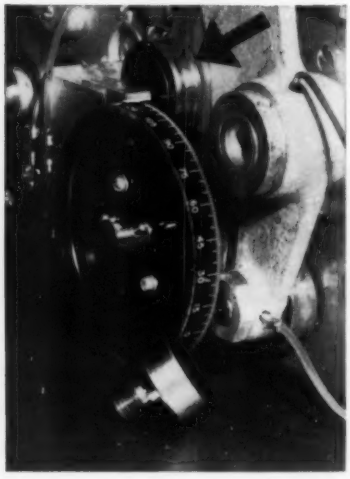
FAWICK AIRFLEX DIVISION magnetic clutches employ McGILL special ball bearing

A special McGILL precision ball bearing was developed to meet the exacting anti-friction requirements of the Fawick Stationary Field Magnetic Clutch. This extremely narrow and thin section bearing of comparatively large bore diameter is built to precision tolerances to accurately position and align all moving parts in relation to the stationary coil. Radial fit up is closely controlled to provide accuracy of magnetic flux air gaps. Retainer is nonmagnetic. Fawick relies on the McGILL bearing to facilitate the rapid and smooth response of the clutch even when operating at high cyclic rates.



McGILL bearings in record-breaking MERCURY outboard motors

Hydroplane speeds averaging over 107 miles per hour, runabout endurance runs of 50,000 miles in 68 days and outstanding power exhibitions by Mercury outboard motors are a true test of component performance. McGILL split center main bearing sleeves are used in 60-80 horsepower six cylinder Mercury outboard motors and have played an important part in the high standards of performance set by these motors.



CAMROL® bearings protect reliability of IBM accounting machines

McGILL CF Series CAMROL bearings improve performance and provide an additional safety factor for greater reliability in IBM 407 Accounting Machines. The CAMROL bearings are located on the card feed cam follower arms and they operate a pressure plate on the sensing unit of this high speed card feed. The IBM 407 Accounting Machine combines outstanding arithmetic ability and printing at a speed of 150 lines per minute.

engineered electrical products

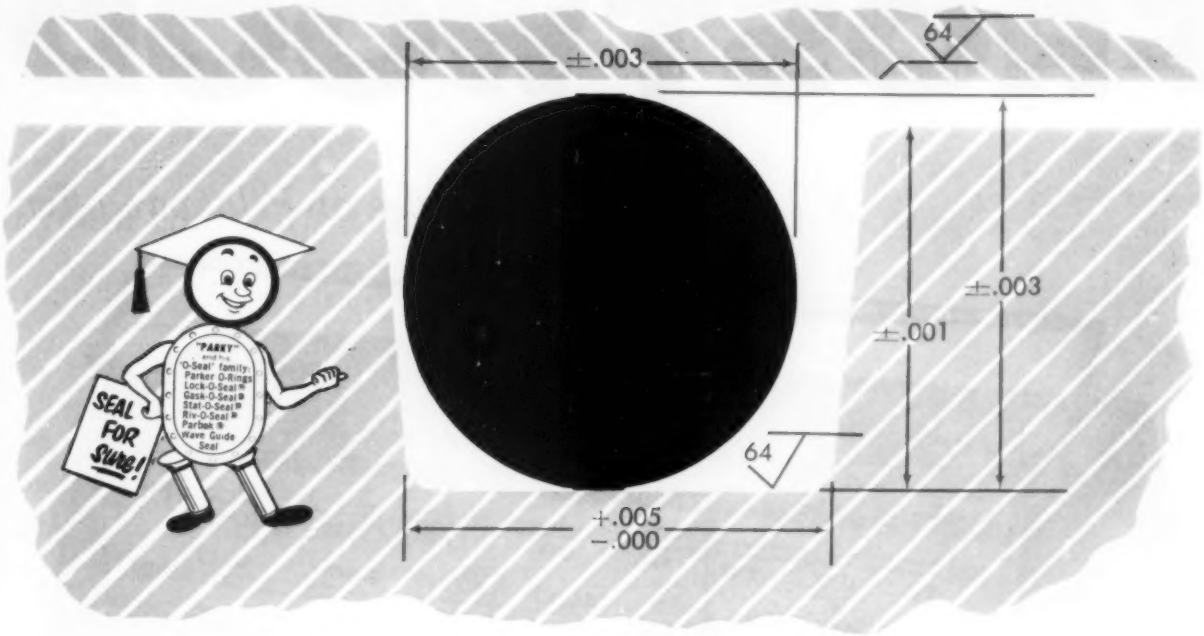
McGILL®

precision needle roller bearings

Send for free copy of McGill Bearing Catalog No. 62.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana



Cancel These Tolerances Specify GASK-O-SEALS®!

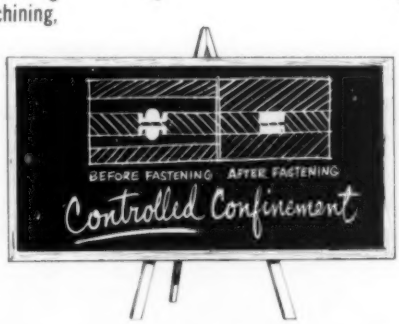
There are more than 5 vital dimensions in the standard O-ring-in-groove installation. Just one of these dimensions, if out of tolerance, can cause an imperfect seal and a resultant leak. Moreover, these tolerances can build up adversely **without always being detectable.** For instance, the total build up in a regular static o-ring gland design amounts to as much as 51% of cavity. It's only 3% in a Gask-O-Seal!

The problem of tolerances is eliminated when you use Gask-O-Seal . . . It's taken care of in its unique design and manufacture using the principle of **controlled confinement.** Gask-O-Seals eliminate 95% of inspection time. **Absolute reliability is built-in.**

In addition, Gask-O-Seals provide metal-to-metal contact, low fastening torques, visual inspectability after installation, no groove machining, and re-usability.

All of this means real no-leakage dependability . . . **the utmost in gasket reliability.**

Why not get **all** the facts about this versatile no-leakage seal. We'll be glad to send you complete information.



THE VERSATILITY OF GASK-O-SEALS IS SHOWN BY ABOVE SAMPLES — ONE OF THEM SEALS 3 DIFFERENT MEDIA AT 9 POINTS — ALL IN **ONE** GASKET!

Parker SEAL COMPANY

Culver City, California and Cleveland, Ohio

CIRCLE 37 ON READER SERVICE CARD

FROSTWOOD

. . . molded articles of Pelaspan offer

An exciting new dimension of *texture* is captured in *Frostwood** molded articles . . . produced by injection molding Pelaspan® expandable polystyrene beads. *Frostwood* molded articles have a distinctive swirled texture reminiscent of rich, fine wood grain. Because the wood grain pattern never repeats itself exactly, every article becomes an original.

*TRADEMARK

a foam core with a hard, textured skin!

The ability to create *Frostwood* molded articles offers designers a vast, untapped potential for products of every description . . . for housewares, such as carafes and thermal tumblers . . . furniture parts, such as chair backs . . . appliance shells . . . and for other design applications where appearance is a major consideration.

Frostwood molded articles are made by injection molding Pelaspan expandable polystyrene beads. A special technique produces molded articles having a lightweight core of foamed polystyrene with durable, shock-resistant, textured surface. *Frostwood* articles offer high thermal insulating efficiency, plus unique one-of-a-kind texturing which gives *Frostwood* molded products eye-catching, sales-making beauty.

Frostwood molded articles can be produced from Pelaspan by a special technique, on most standard injection molding equipment. There are few limitations on shape and contour. Here are almost unlimited new product design possibilities!

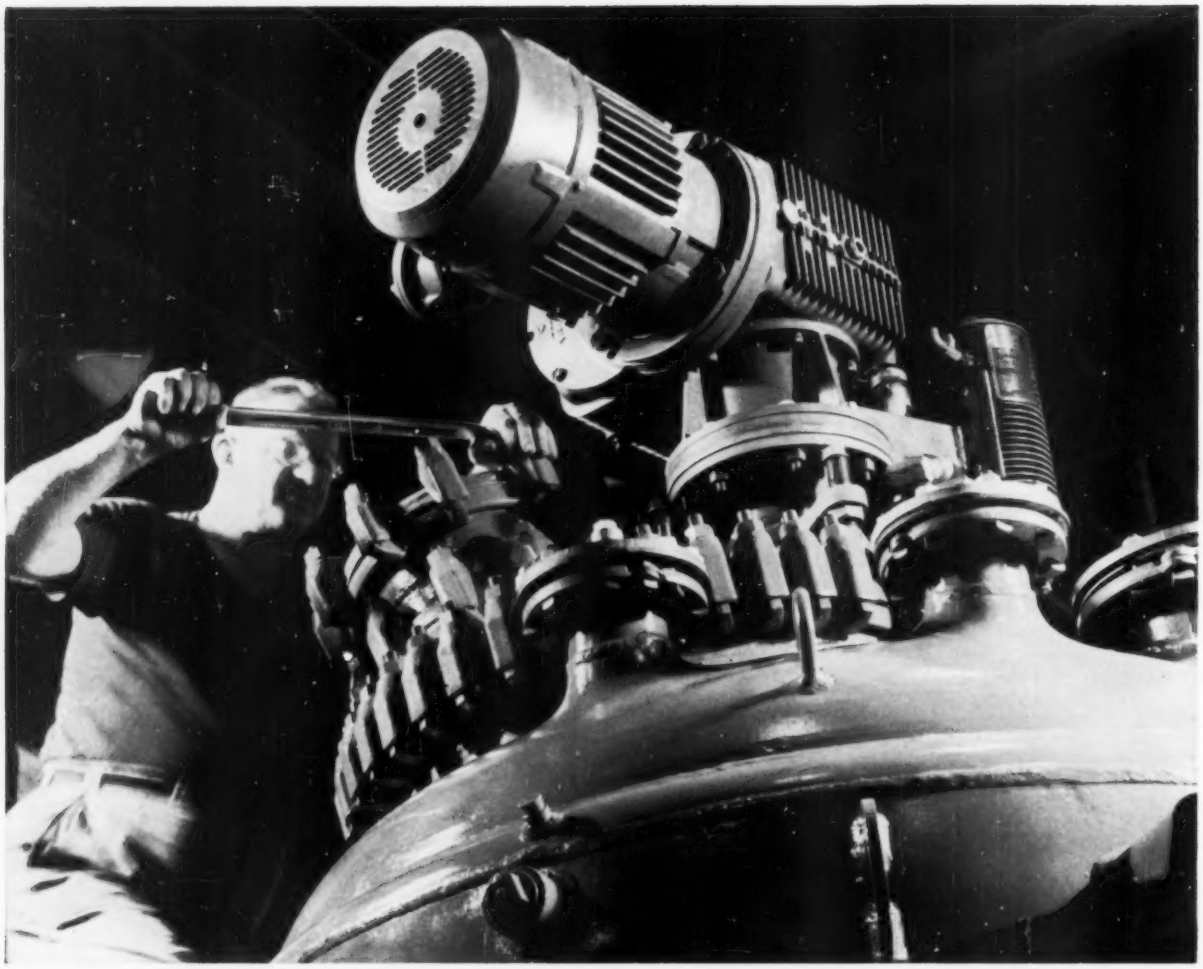
Dow Plastics Technical Service Engineers will help you adapt this material to your design problems. Write us today in Midland, C/O Plastics Sales Department 1722DZ12-11.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

ELECTRIC SHOE BUFFER by Royal Master. Styron® plastic offers wide color range, high impact strength and light weight to this unique product.

ELECTRIC CAN OPENER by Westinghouse. Colorful housing of Styron plastic combines excellent moldability with food and chemical resistance.

EXHAUST FAN by Berns Air King. Grille of high-impact Styron plastic resists shock and vibration. Grease and stains wipe clean in a jiffy.



Compact, Dependable, Quiet and Powerful——

that's what The Pfaudler Co. demands of gear reducers used for the agitator drives on their glassed-steel and alloy mixing vessels. That's why Pfaudler specifies Cone-Drive double-enveloping worm gear reducers for their line of TW Agitation Drives.

Cone-Drive gear reducers are available in capacities up to 60 HP and with 27 standard output speeds from 7.3 to 525 rpm (with 1750 rpm motor). Gear reducers can be hollow-shaft or solid shaft for left-hand, right-hand or vertical mounting.

Hollow-shaft gear reducer shown in the application above has a 5″ center distance and 30 HP maximum rating. Fan cooled models are available for increased thermal capacity. If maximum thermal HP capacity is required (equal to full mechanical HP ratings), water cooling coils may be installed.

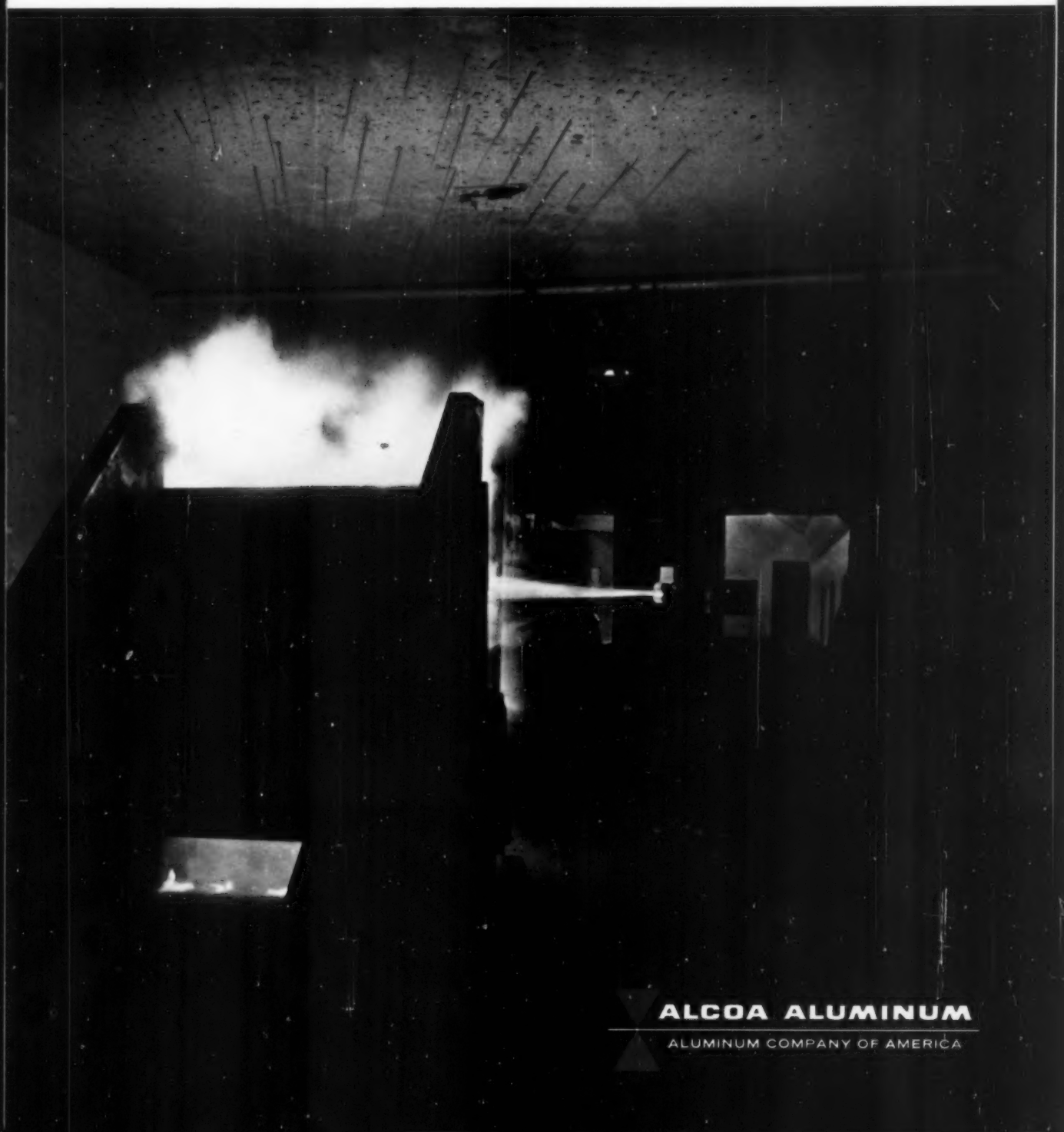
CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • *Telephone* TWinbrook 1-3111

CIRCLE 40 ON READER SERVICE CARD

CIRCLE 41 ON READER SERVICE CARD →

When an aluminum weld stops a 37mm high-explosive shell...



ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

When an aluminum weld stops a 37mm high-explosive shell . . .

that's Alcoa Total Ability at work!

Blam! A 37mm high-explosive shell slams home right into the weld. It holds, and weldable Alcoa® Aluminum Armor Plate passes its last test. Next stop: armored vehicles for our defense forces, giving personnel the protection of steel at a saving in weight . . . adding vital speed, range and air-borne mobility.

This 1¼-in. "H" plate of Alcoa Alloy 5083 is welded by the inert gas shielded method, using Alcoa 5356 consumable electrode. Aluminum is *field-weldable!* Portable gear goes along by jeep or mechanical mule, independent of power or cooling water.

Whatever the joining method for aluminum, you get more savvy (and the best materials) from Alcoa. It follows. Alcoa perfected most of the Welding, brazing or soldering? Alcoa kno how to boost quality, hold down costs. For m chanical fastening Alcoa makes bolts, nuts, rive washers, screws and "specials" to your ord And they're made of the proper alloy, fully hea treated to insure lasting strength.

Alcoa also supplies aluminum sheet and pla extrusions, impacts and castings in all alloy tempers and finishes. Stands to reason, the we've no favorites among them. Your needs c the shots for *Alcoa Total Ability!* Find out mo from the Alcoa sales office near you, or writ Aluminum Company of America, 857-M Alc Building, Pittsburgh 19, Pa.

Entertainment at Its Best . . . **ALCOA PREMIERE** with Fred Astaire as Host . . . Tuesday Evenings, **ABC-TV**

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

ALCOA ALUMINUM: EASY TO JOIN BY ANY METHOD!

1. Aluminum pleasure boat combines light weight and high speed with the rugged strength and durability of all-riveted construction.

2. Aluminum superstructure for the guided-missile destroyer *U.S.S. Dewey* uses Alcoa alloys welded by IG consumable-electrode method.

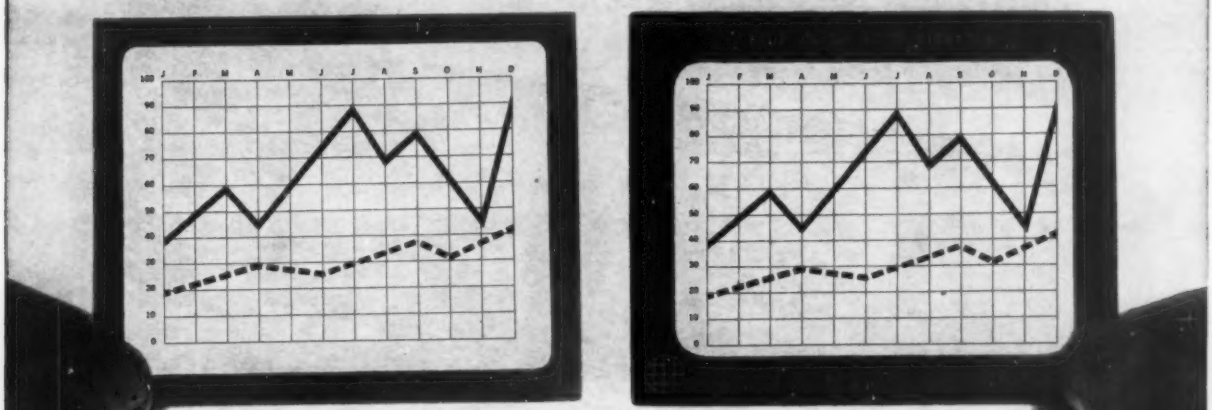
3. Alcoa Aluminum superstructure for electrical transmission tower is made of welded subassemblies, bolted together in the field.

4. Aluminum leisure furniture made of Alcoa welded tube keeps its smart good looks for years, fastened *right* with rustproof aluminum rivets, sheet metal screws.

5. All-aluminum electrical substation: Special wide-flange beams are bolted; main and line section buses and taps are welded tube.

6. All-aluminum personnel boat is Alcoa Alloy 5456. Welded *faster* than steel, it ends sandblasting, metalizing, stress-relieving.

"POLAROID" AND "POLALINE" ®



$1.50
24 Hours
Film Processor

55¢
90 Seconds
Yourself
(with a Polaroid Land Camera)

To make your own black-and-white slides – quickly and economically – here's all you have to do: snap a picture with a Polaroid Land Camera loaded with special transparency film. Then pull a tab, wait a moment and open the rear of the camera.

There's your transparency.

After a quick hardening and mounting in a snap-together frame, the slide is ready to be dropped into a projector. Total time: about 90 seconds. Total cost: about ⅓ the price of the average black-and-white slide.

A new type of transparency film, PolaLine film, is now available. It's been designed especially for line-copy slides and it produces crisp, black lines and clear, transparent backgrounds. These are 3¼ x 4 transparencies for standard lantern slide projectors.

There are also continuous tone films for both standard lantern slide projectors and for use in a complete Polaroid Land system that employs 2¼ x 2¼ slides in a Polaroid projector. (Development time for continuous-tone slides is two minutes.) All three projection film types can be used in any Polaroid Land Camera that uses 40-series films (except the J-66).

Sound good? It is. There's no better way to make transparencies. Send in the coupon for more information.

Polaroid Corporation
Technical Sales Dept. PE-12
Cambridge 39, Mass.

Please send me detailed information about Polaroid Land transparencies.

Name_____

Address_____

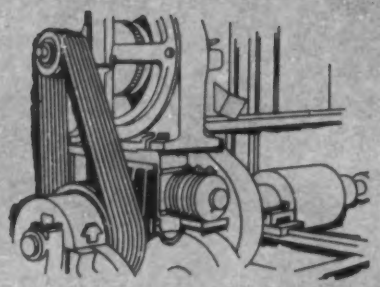
_____

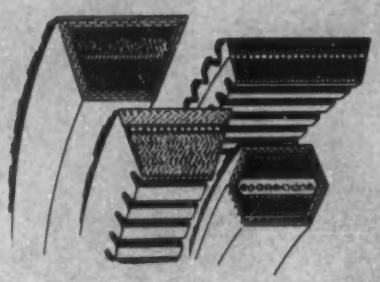
City_____

Zone_____ State_____

CIRCLE 43 ON READER SERVICE CARD 43

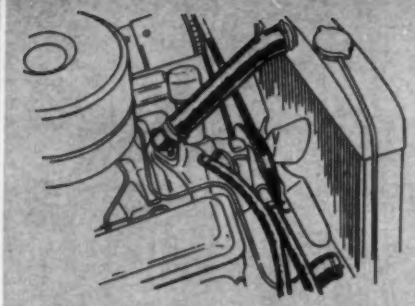
V-BELT DRIVES

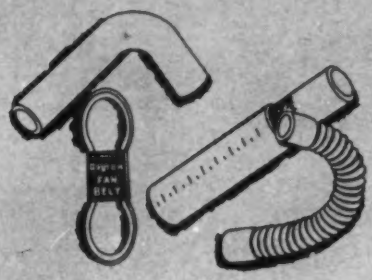




Dayco offers the only complete line of V-Belts in the industry for every power transmission need—from fractional to 1,000 and more horsepower.

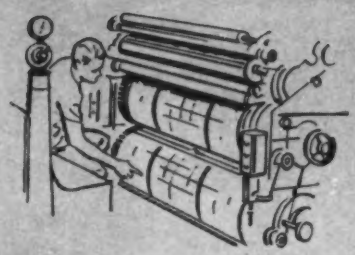
AUTOMOTIVE PRODUCTS

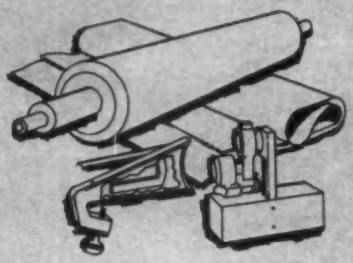




Dayco provides a complete line of Fan Belts, Radiator Hose, and other rubber products for passenger cars, trucks, busses, and tractors.

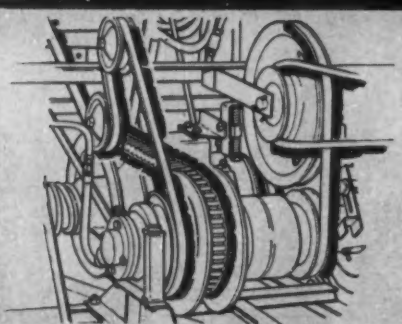
PRINTING PRODUCTS

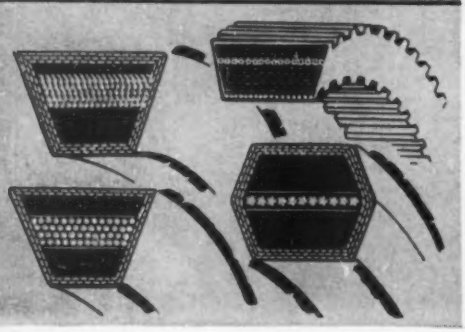




Dayco offset and letter press rollers, Gold Seal offset Blankets, Color Separators and Fountain Dividers, for all makes of presses.

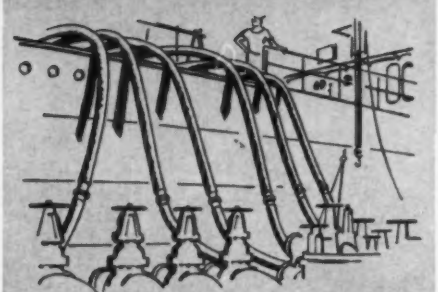
AGRICULTURAL V-BELTS

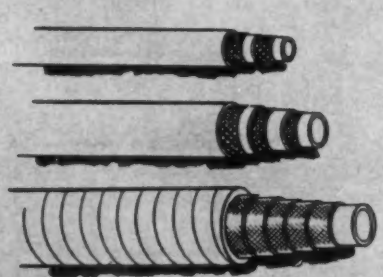




Dayco builds specialized V-Belts for the efficient transmission of power on all types of traction, propulsion and auxiliary farm implement drives.

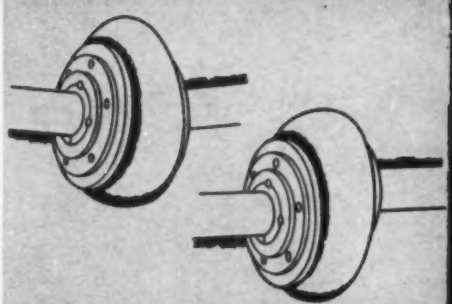
INDUSTRIAL HOSE





Dayco offers molded and horizontal braided, machine and hand wrapped fabric, and woven jacket constructions for all industrial applications.

MOLDED RUBBER



Dayco custom-engineered molded rubber, rubber-to-metal and rubber-and-fabric components for mechanical applications.

Dayton

Take your pencil. Get all the Day**ton** literature from your files. Make one little change. In place of Day**ton** write Day**co.**

From now on, that's our product name. **Dayco** V-Belts. **Dayco** Hose. **Dayco** Printing Rollers and Blankets. **Dayco** Molded Rubber. **Dayco** Agricultural and Railway Drives.

Thus ends the difference between our corporate name, Day**co** and our **former** product name, Day**ton.**

Let us repeat. The only thing that's changed is the name. The same high quality. The same broad line. The same friendly, helpful people. Only their product line is now **Dayco. DAYCO. D-A-Y-C-O.**

Dayco CORPORATION

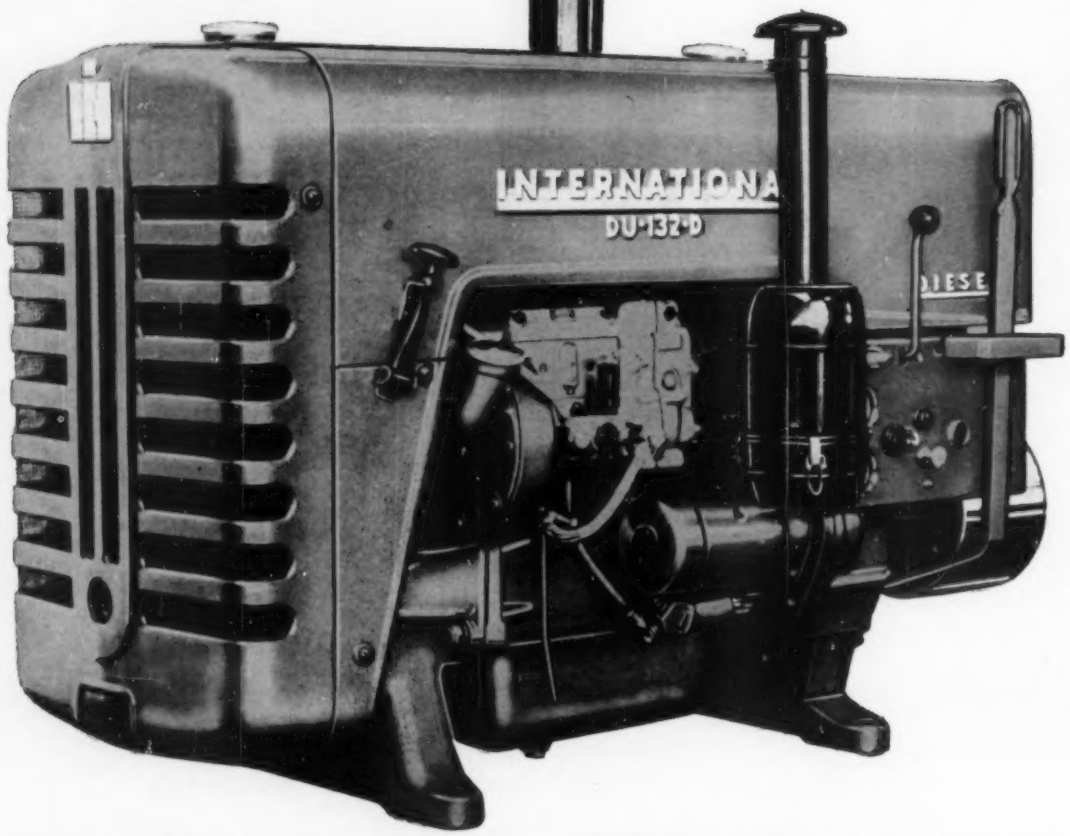
Rubber Products Division — Melrose Park, Illinois

(Formerly known as The Dayton Rubber Company)

CIRCLE 45 ON READER SERVICE CARD

CIRCLE 46 ON READER SERVICE CARD→

5 NEW DIESELS



- **Heavy-duty design in a compact engine**
- **Smooth, high-speed operation**
- **Interchangeability of wearing parts**
- **Controlled temperature cooling**
- **Gear pump force-feed lubrication**
- **12-volt electrical system**
- **Push-button glow plug starting**
- **Famous International parts and service**

SPECIFICATIONS

Model	No. Cyl.	Bore x Stroke	Disp. (cu. in.)	Length (in.)	Width (in.)	Height (in.)	Engine Weight (lb.)	Max. hp	Int. hp	Cont. hp	Torque (lb./ft.)	Fuel Consumption (lbs./hph)
DU-66D	2	3.25 x 4	66.3	21.22	20.25	30.37	408	15.8	14.2	12.6	36.5	.457
DU-74-D	2	3.44 x 4	74.3	21.22	20.25	30.37	410	17.4	15.7	13.9	42.5	.457
DU-99-D	3	3.25 x 4	99.5	25.50	23.09	30.00	520	22.8	20.5	18.2	65.0	.477
DU-111-D	3	3.44 x 4	111.3	25.50	23.09	30.00	524	24.6	22.2	19.7	72.0	.477
DU-132-D	4	3.25 x 4	132.7	29.75	23.00	30.12	589	39.6	35.6	31.6	97.0	.464

Horsepower ratings shown above are for engine with fan, radiator, clutch, air filter and generator at 2,000 RPM except for UD-132-D which is 2,400 RPM. Max. torque at 1,200 RPM. Dimensions and Weights are from fan to back face of flywheel housing and do not include PTO or air cleaner.

12 to 40 hp

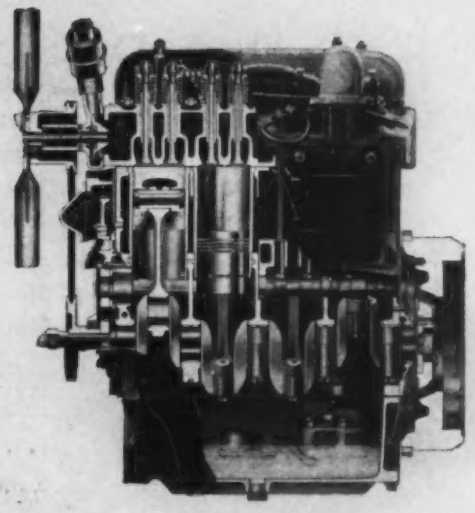
International sets new standards of performance with heavy-duty design in compact, economical engines..,

Here's eager, dependable power for those jobs where the load is moderate but the duty is rugged. Now you can put a hefty, field-proved International Diesel on water pumps, water well drill rigs, refrigerating units, generators, conveyors, lift trucks, tractors, compressors, asphalt mixers, blowers, sprayers, compactors, cranes, pipeline equipment, locomotives and small crushers. These two, three and four cylinder International Diesel engines, from 12 to 40 horsepower, bring the complete IH line up to 62 models—including the largest line of Diesels in the industry.

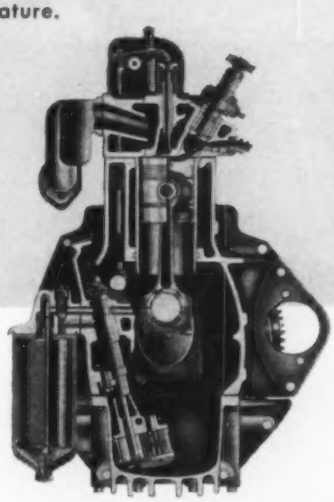
All five models are direct-starting, valve-in-head, sleeved engines with 19.1 compression ratio. The power unit hood is hinged for easy access to fuel tank, cooling system, oil pan and battery. Operating levers and instruments are grouped for easy, one-hand control and operator convenience. Maximum flexibility is achieved with optional attachments—you specify exactly what you need, from bare engine to complete power unit.

Check the full IH line of Diesel and carbureted engines—8 to 385 hp—and discover the extra selling advantages International power adds to your products. Call or write to International Harvester Co., Engine Sales Dept., Melrose Park, Ill.

Simple, rugged design assures maximum efficiency and easy servicing...



Economical operation is assured with full-firing efficiency of IH swirl-type pre-combustion chambers. Built-in governor maintains selected rpm despite varying loads. Replaceable main and connecting rod bearing shells have extra large bearing surface for longer operating life. Gear pump force-feed lubrication assures continuous flow of lube oil to all bearing surfaces. Pump-circulated cooling system with thermostatic control and radiator curtain provides quick warm-up and efficient operating temperature.



Interchangeability of many parts and attachments brings you unmatched advantages in power standardization

These new IH engines are designed with interchangeable connecting rods, main and connecting rod bearings, valves, valve springs, push rods, and rocker arm assembly components. Crankcases are machined from three basic blocks, and pistons and sleeves are of two sizes. Many attachments are interchangeable. And you get further model-matching advantages with the smaller carbureted engines in the International line.

INTERNATIONAL®
ENGINES

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.
A COMPLETE POWER PACKAGE

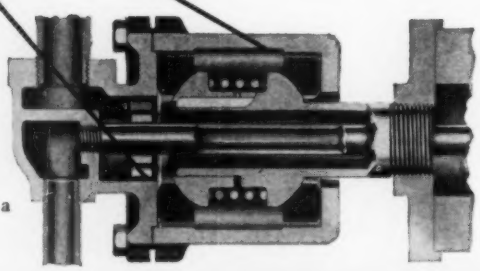
GRAPHITAR®

(CARBON-GRAPHITE)

FOR PERFORMANCE

Superior performance and unusually long service life, even in tough applications, is practically second nature to parts made of GRAPHITAR. That's because they combine GRAPHITAR's chemical stability, heat resistance, low coefficient of friction, adaptability to self-lubrication, mechanical strength, hardness and light weight. An everyday application of GRAPHITAR that illustrates well its versatility and remarkable performance can be found in the face-type valves employed in bulk station gasoline meters. These valves incorporate GRAPHITAR seats.

Here, GRAPHITAR's corrosion resistance, chemical inertness and resistance to expansion or contraction under rapid temperature changes, allow the valves to provide a leak-tight seal with excellent wear characteristics. These same characteristics are necessary for good performance wherever steam, gas and chemicals must be handled under the most adverse conditions. Perhaps your product can benefit from the top performance of GRAPHITAR, a unique and versatile engineering material.



Self-aligning seals of GRAPHITAR are employed in rotary pressure joints handling steam, water, hot oil, trichlorethylene, powdered talc and a variety of chemicals.

R-302-1

Comparative testing of various grades of GRAPHITAR self-aligning seals is accomplished on this equipment, which duplicates actual operating conditions. GRAPHITAR rotary pressure joint seals such as these often operate at 400 psi, at 650°F. and at rotary speeds of 600 ft/min.

GRAPHITAR is a material uniquely designed by its nature for solving tough problems and improving processing, and it can be further custom-engineered to meet your exact specifications. For complete information on GRAPHITAR . . . send for Engineering Bulletin #20.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Convertible Trouble Free Contacts...Tens of Millions of Operations
A-B
QUALITY
Bulletin Type BR Control Relay with one pole changed over to the normally closed position.
Type B General Purpose 8 Pole Control Relay
Type BX 4 Pole Construction Universal Relay
NEMA Type 1 Enclosure for all Relays

In 9 out of 10 cases the Type BR Relay will far outlast its original service application

Even in the toughest service, Allen-Bradley Bulletin 700 relays provide those "extra" millions of trouble free operations that keep production high and down time low. In addition, no other relay offers industry such ready flexibility as the Type BR with their easily convertible contacts, plus the possibility of adding two contacts out in the field. Changeover from normally open to normally closed (or vice versa) takes only seconds! Thus a four-pole unit provides any of the contact combinations you can obtain with *five different* relays having the usual fixed contacts—a real answer to relay inventory problems. Also, the Type BR relays have a built-in permanent air gap that completely eliminates magnetic sticking.

The molded coil is impervious to *all* harmful atmospheres. And the double break, silver contacts—standard on all A-B relays—never need attention of any kind.

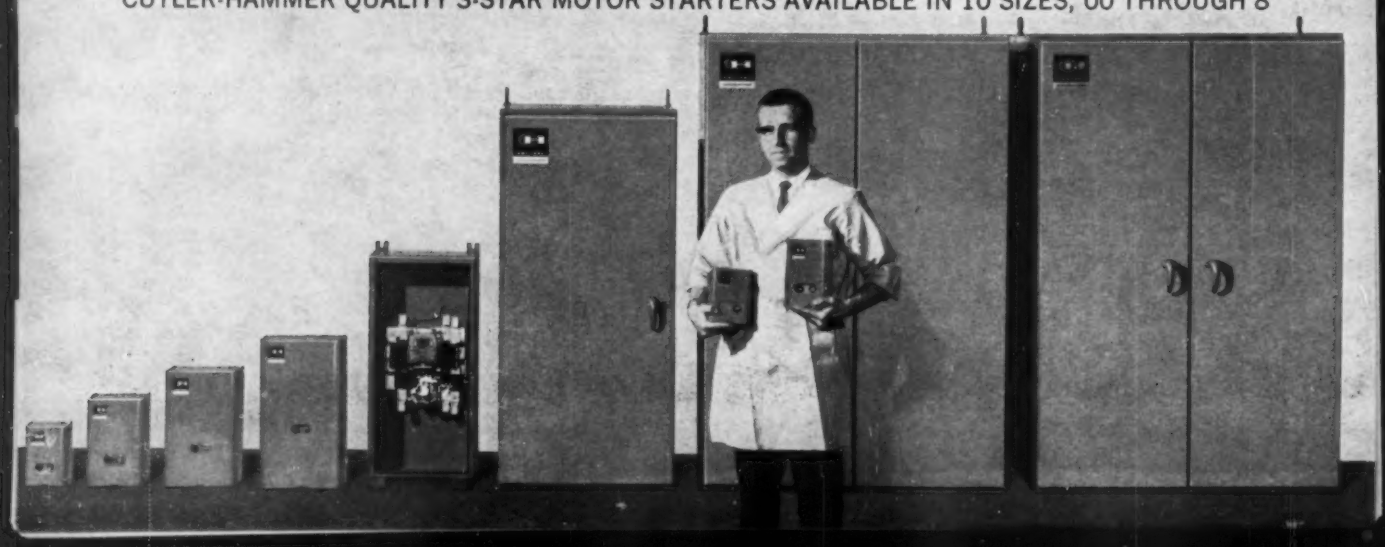
The popular Allen-Bradley Type B, general purpose, and Type BX, universal, relays incorporate many advanced features to insure long, trouble free life. The new structural design increases mechanical life *at least 5 times*. A new contact motion increases electrical reliability *at least 10 times*.

For full details on the complete A-B line of *Quality* relays, please send for Descriptive Bulletin 700: Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario.

ALLEN-BRADLEY / ***QUALITY MOTOR CONTROL***

Member of NEMA

CUTLER-HAMMER QUALITY 3-STAR MOTOR STARTERS AVAILABLE IN 10 SIZES, 00 THROUGH 8



CUTLER-HAMMER MOTOR STARTERS

Still the proven standard of quality...always in stock for immediate delivery

Millions of satisfactory operations in thousands of applications have proved the unmatched quality of Cutler-Hammer across-the-line magnetic starters. That this line is still recognized as the leader—nine years after the original design was developed—is a great tribute to the years-ahead thinking of Cutler-Hammer engineers.

FIRST IN '53—STILL THE LEADER IN '61

Since the Three Star line was introduced in 1953, many improvements have been made; magnet coils that far exceed NEMA standards, for example. But many achievements of the original design—vertical, dust-free contacts; overload relays adjustable to within 3% of actual full-motor ratings; provision for 2 or 3-coil overload relays in the same enclosure—are features no other manufacturer has been able to improve. You can safely bet that when these pace-setting features are improved, it'll be another Cutler-Hammer development.

ALWAYS AVAILABLE FOR FAST DELIVERY

You'll find the smaller sizes of Cutler-Hammer Starters always in stock at your local distributors—larger sizes immediately available from the factory. We hope you'll make your own feature-by-feature comparison between the Cutler-Hammer line and any other starter on the market. Look especially carefully at such vital advantages as ease of installation, high interrupting capacity, coil construction and accessibility.

Regardless of what features you select as the criterion of superiority, we're sure you'll choose Cutler-Hammer after you've made your unbiased comparison.

If you're one of many companies being forced to stock two sets of parts because of design changes, now is an excellent time to standardize on Cutler-Hammer.

Call your distributor or local Cutler-Hammer Sales Office soon. Or write for Publication LO-70-Y249.

WHAT'S NEW? ASK..

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

CIRCLE 51 ON READER SERVICE CARD

ROLLPIN is the slotted tubular spring pin with chamfered ends that is cutting production and maintenance costs in every class of industry. Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. ROLLPIN is readily removable and can be re-used in the same hole. Made in carbon steel, corrosion resistant steel and beryllium copper.

"WHERE SHOULD YOU BE USING ROLLPINS®?"

Thousands of companies—from cigarette lighter makers to car manufacturers—have learned from experience that ROLLPINS not only cut production and assembly costs, but make good products even better! The 9 examples pictured below don't even begin to indicate the range of application and usefulness of this simple, universal fastener. And naturally, they don't begin to show the cost and production savings you can achieve with ROLLPINS. If you aren't using ROLLPINS now, shouldn't you be? Write for a generous sample assortment and complete information. Dept. R62-1245.

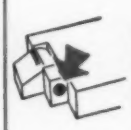
ROLLPIN REPLACES 9 DIFFERENT FASTENERS!

REPLACING A GROOVED PIN . . . here Rollpin serves as a stop pin. Its light weight and shear strength function perfectly . . . cuts assembly costs.

REPLACING A SET SCREW . . . a short length Rollpin is self-retained in the handle of an automobile brake. Is readily driven into over-drilled hole in shaft for easy removal.

REPLACING A HEADED PIN . . . in this hinge pin application, constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary. Faster assembly.



REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member.

REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. Rollpin's shear strength is particularly valuable here.

REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

REPLACING TAPER PINS . . . Rollpin eliminates cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper.

REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots . . . may also be used with a free fit in outer or inner members depending upon product design requirements.

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 Vauxhall Road, Union, New Jersey

ROLLPIN®

CIRCLE 53 ON READER SERVICE CARD→

BEST for... SPLIT-SECOND TIMING

for laboratories • production control • test equipment • time-motion studies
wherever precise measurements are needed!

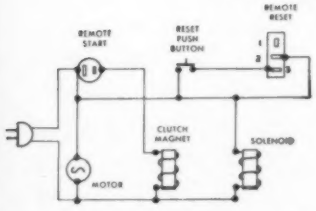
ELECTRIC STOP-CLOCK

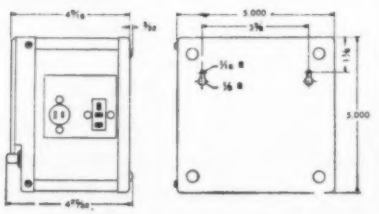
SC 100

with exclusive new INSTANT STOP Cone Clutch

Now stop-clocks go versatile—with the SC 100, the ideal timing instrument where short, precise measurements are required. It starts, stops and resets automatically in milliseconds. The SC 100 features a unique cone clutch which engages the pointer mechanism with the synchronous motor. So rapid is the clutch engagement that no dial compensation is required for pull-in lag. An additional feature is a solenoid-operated pointer reset which completes a full dial reset in approximately 100 millseconds. A compound dial is employed using two pointers, the inside dial registers from 1 to 60 seconds in 1 second increments. The outside dial measures from .01 to .99 seconds in .01 second calibrations. Write for Bulletin #702 and get the full details why this is the timely answer to your timing problems.

ENGINEERING SPECIFICATIONS





The SC 100 Electric Stop-Clock is only one example of the thousands of precision engineered timing controls contained in our 50-page, fact-packed catalog. It will pay you and your firm to have a copy of this valuable volume. For a free copy, write us on your company's letterhead.

INDUSTRIAL TIMER CORPORATION

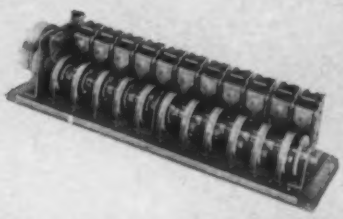
1403 McCARTER HIGHWAY • NEWARK 4, N. J. U.S.A.

CANADA: SPERRY GYROSCOPE OTTAWA LTD., 3 HAMILTON AVE., OTTAWA, CAN. • PA 8-4681

UP TO THE MINUTE IN DESIGN DOWN TO THE SPLIT SECOND IN ACCURACY!

SERIES TDAB TIME DELAY TIMERS

Designed for applications on circuit controls where an adjustable or fixed time delay is required between the opening or closing of one circuit and the predetermined opening or closing of another circuit. Back mounted and automatic reset. Write for Bulletin #300 for full details.

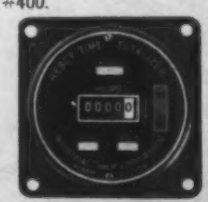


SERIES MC PROGRAM CAM TIMERS

Repeats a continuous, adjustable ON and OFF electrical cycle. Standard cam construction is such that the ON-OFF cycle can be adjusted from 2% to 98% of the total time cycle. Individual cam adjustability enables the timer to be used as a programming device with up to 20 switches. Cams can be adjusted, rapidly and easily, in any combination of timed sequences. Write for Bulletin #200.

SERIES PAB INTERVAL TIMERS

Close a load circuit for a pre-set time interval. Automatically resets at the completion of the time cycle. Extremely accurate timing mechanism built to stand up under the hard usage and demanding standards that modern manufacturing processes require. Write for Bulletin #400.



MODEL C-5 RESET TIME TOTALIZER

Provides extreme accuracy where elapsed time meters are required to show an exact record of machine operating hours. Reset wheel protrudes slightly out front of panel for easy thumb adjustment. Precision engineered throughout according to Industrial Timer standards. Write for Bulletin #700 for details.

Identify durable, modern steels in your products. Use this label.

ALUMINIZED STEEL Type 1 has been used in exhaust system parts for years. One of the newest is this spark arrester for trucks and tractors. In forest areas, it traps exhaust sparks.

Design for durability Armco Coated Steels

For strength with economy, steel is still the best answer. And special Armco Steels, with coatings of zinc or aluminum, offer unmatched selection for *low-cost durability, too.* They are designer's materials, with built-in economy.

Zinc-coated Armco Steels are produced with or without spangles. All grades can be mill-treated for immediate painting. Aluminum-coated Armco ALUMINIZED STEEL Type 1 resists a combination of heat and corrosion. Its companion, Type 2, gives products outstanding service life outdoors because of its superior atmospheric corrosion resistance.

All Offer Savings

Small stampings from Armco ZINCGRIP® save 2.8 cents apiece for one manufacturer by eliminating cadmium plating. With new *spangle-free* ZINCGRIP A, PAINTGRIP®, another manufacturer achieves paint finish equivalent to that on cold-rolled steel. Besides, his product is assured of much longer paint life and over-all rust resistance.

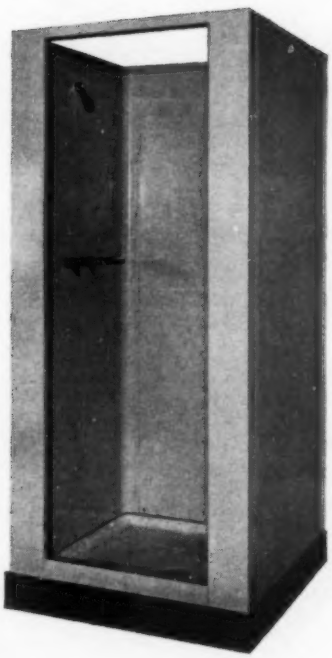
Heater makers take advantage of the fact that Armco ALUMINIZED STEEL Type 1 outlasts all other metals in its price class when exposed to combinations of heat and corrosion. A producer of outdoor clothes dryers finds Armco ALUMINIZED STEEL Type 2 gives material savings of 30% over aluminum.

Perhaps one of these special Armco Coated Steels can help *you* design for savings, too. Mail the coupon for complete information.

ARMCO

Armco Division

LOW-COST with



In shower stalls, new Armco ZINCGRIP A, PAINTGRIP provides special advantages. First, its spangle-free surface promotes ultra-smooth paint finish. In addition, it has full zinc protection against rust plus the sturdy strength of steel.

New steels are born at Armco

Armco ALUMINIZED STEEL Type 2 serves in the casing for this outdoor clothes dryer. The manufacturer cites strength, good looks, outstanding resistance to rust, and 30% savings over aluminum as reasons for its use.

Armco Division, Armco Steel Corporation
2091 Curtis Street, Middletown, Ohio
PLEASE SEND information on:
☐ Armco ZINCGRIP and ZINCGRIP PAINTGRIP (spangled)
☐ Armco ZINCGRIP A and ZINCGRIP A, PAINTGRIP (spangle-free)
Armco ALUMINIZED STEEL ☐ Type 1 ☐ Type 2

NAME _____

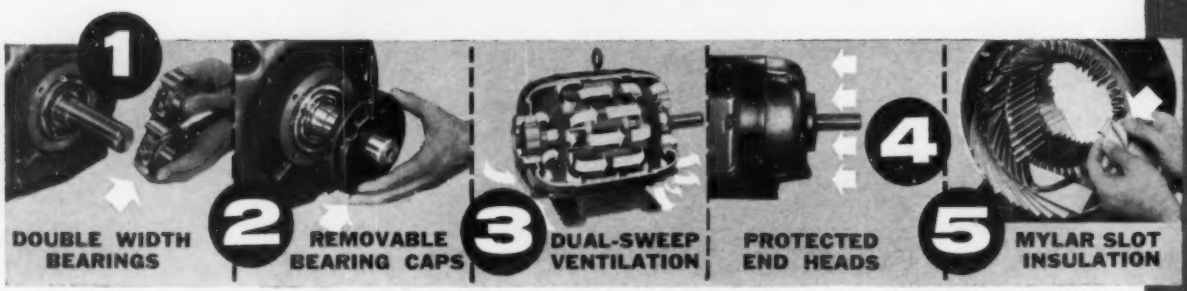
FIRM _____

STREET _____

CITY _____ ZONE _____ STATE _____

WHICH R&M MOTOR FEATURE WILL ADD MORE TO YOUR PRODUCT'S

COMPETITIVE ADVANTAGE?



All these outstanding features—*yours at no extra cost*—contribute to R&M's dependable performance, easy maintenance and long life. Fully sealed double-width bearings have extra-large reservoirs containing grease selected to resist dust, temperature, humidity and high speeds. Bearing inspection and relubrication are easy. Bearing cap on each end head comes off quickly when four bolts are removed. Bearing seal, held by removable snap rings, is also easily removed. "Dual-Sweep" ventilation greatly prolongs motor life with high-velocity cooling and cleaning. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas. Venturi baffles direct air over and around end coils. One-piece shrouded end heads give full-height protection against moisture and falling objects. Mylar* laminated to rag paper insures positive slot cell insulation because of its excellent dielectric qualities (8 times that of conventional insulation). Rag paper backing provides cushion against abrasion and puncture. Get complete information . . . write today for Bulletin 520-PRE

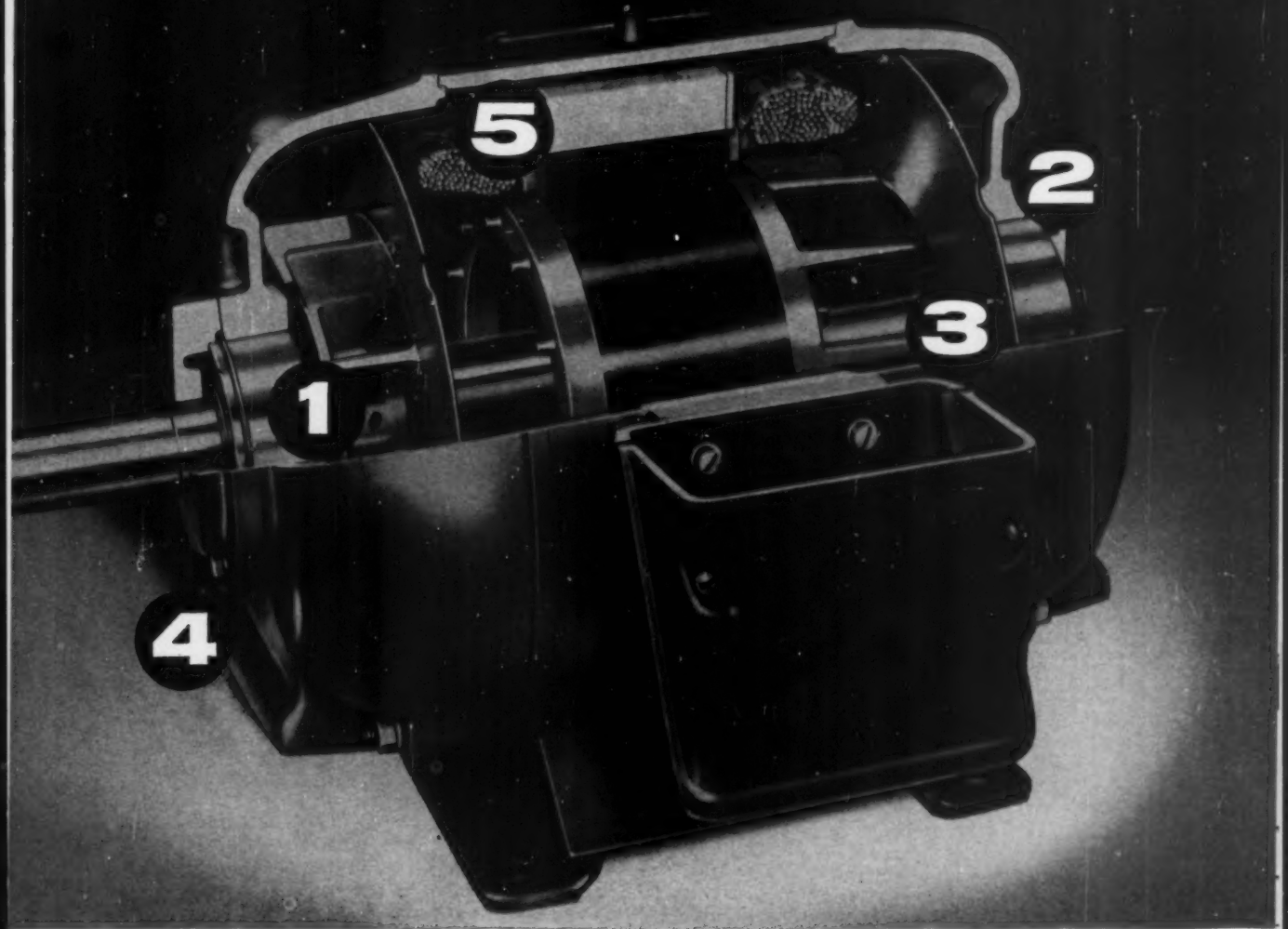
**DuPont registered trademark*

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)

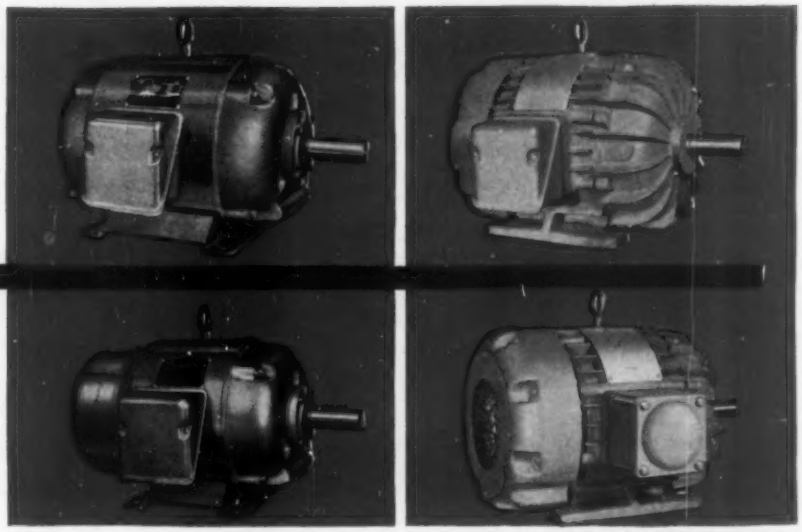


Open Protected Polyphase Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

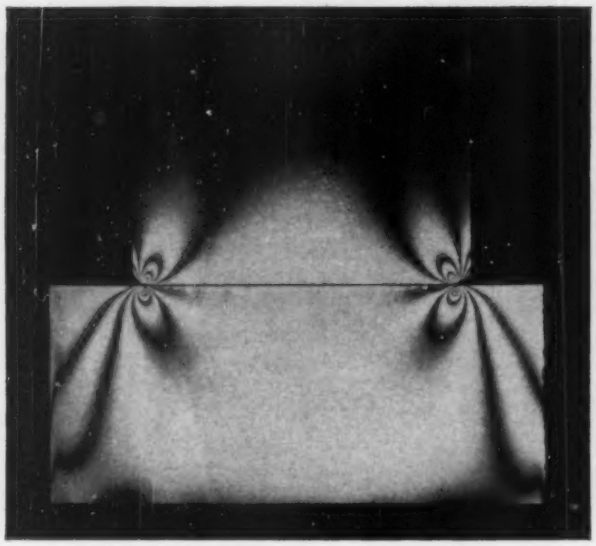


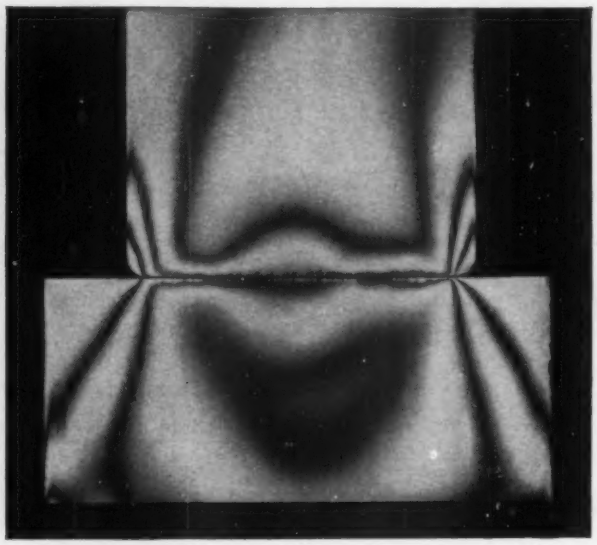
CIRCLE 57 ON READER SERVICE CARD

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

DEVELOPMENTS TO WATCH

Better lubricants for the 600-F range, new nodular irons, and better glasses for radiation shielding are coming from research on "rare-earth" metals.

These metals—no longer rare—have been under intensive study for many applications in the last few years, are already providing new electronic and optical materials (*PE—Apr* 25 '60, *p* 39 *and Aug* 24 '59, *p* 13).

Now, Naval Research Lab reports that rare-earth additions—notably cerium—will stabilize silicone oils against oxidation and gelation in the 550-650 F range.

Crane Co researchers are using yttrium, another rare earth metal, to produce a partially spherulized nodular iron that's said to offer good strength and toughness.

Penberthy Instruments Lab has a new series of non-darkening neutron shielding glasses that contain a third rare earth: gadolinium.

The stabilized oils are still in the laboratory, and only preliminary reports are available (the latest, NRL 5641, is now being prepared for publication.) The yttrium nodular irons are, however, at the production stage, as are the glasses.

Rare metals, semimetals, and metalloids are also attracting new attention for **semiconductors and thermoelectric converters** as earlier hopefuls, like silicon carbide, resist major research efforts aimed at overcoming their limitations.

As W. C. Dunlap of Raytheon Research points out, difficulties have been encountered in producing large-size crystals of silicon carbide suitable for semiconductor work; and the progress to date in improving thermoelectric materials for power converters and Peltier coolers has been "disappointing." On the other hand, he says, the rare-earth sulfides, particularly those of gadolinium and cerium, seem quite promising for high-temperature thermoelectric applications, and "semimetals"—elements like bismuth—which have relatively low conductivity and overlapping or nearly overlapping conductivity bands may provide a key to new electronic materials. Also extremely promising are pyrolitic graphite and such related materials as boron nitride, for both electrical and electronic use. (A report on these materials will appear here next month.)

Another exotic metal—ruthenium—may soon be on its way to practical structural application. Until now, fabrication problems as well as cost have dampened enthusiasm for this high-melting (4350 F), corrosion-resistant metal. But recent studies at AEI Research Laboratory (Aldermaston, England) indicate that alloying may be the answer.

G. A. Geach of AEI reports that new **high-molybdenum ruthenium alloys show much-improved fabrication characteristics, while retaining excellent corrosion resistance and good high-temperature strength.**

Greatest ductility has been observed in alloys containing about 45% (atomic) molybdenum. Rod stock has been swaged from 0.19 to 0.050 in. dia; and the metal is hard as well as ductile. In the as-cast state, its Vickers hardness is about 445. Cold rolling (54% reduction) increases this to 700. Even at 2200 F, it is harder than tungsten (65 Vickers as compared to 50). Corrosion resistance is such that, Geach predicts, the alloy may be able to replace platinum as an electrode in conductivity measurements where a rigid material is required.

Knives that won't lose their sharpness, and won't rust—even in salt water . . . New temperature-sensing devices . . . Mechanical parts that are lighter, stronger and easier to form . . .

These are only a few of the predictions made for the Navy's new nickel-titanium alloy, announced last month. Right now, though, its still in the evaluation stage; and only small heats have been produced.

The Navy is pushing development of the material because it is not only hard (it can be heat treated to 62 Rockwell C) and resistant to salt water corrosion but

also nonmagnetic—an excellent material for shipboard tools. That's likely to be its first application. Prototypes have already been made.

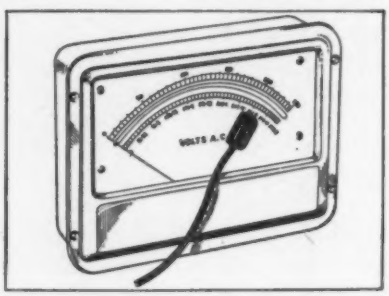
However, the Naval Ordnance Lab scientists who developed the alloy say its excellent nonmagnetic properties plus its resistance to corrosion and the fact that it is tough and can be hardened and welded make it "an ideal alloy for many space and aircraft components." Furthermore, they note, it may have application in jewelry, auto trim, nonmagnetic watch parts, and other commercial items. Because it undergoes marked changes in mechanical vibration damping characteristics with rather small changes in temperature it may also find application in temperature sensing devices.

Actually, the new alloy is only the first of a whole group containing 54.5% or more of nickel, with major amounts of titanium and various percentages of iron—and some compositions are said to show a ductility as high as 15% and impact strengths to 28 ft-lb. Melting points are in the 2370-F range; and the alloys appear to resist oxidation and retain usable strength at least to 1200 F.

• • • •

A photoelectric control unit that takes its instructions from the pointer of a meter has been designed by Sealy Engineering Co Ltd, 33 Avery Hill Road, New Eltham, London SE9, England. It can serve as the basis for a control system that will operate remotely and without direct contact.

The unit is a little black box ($\frac{3}{8}\frac{5}{8}$ by ½ by $\frac{5}{16}$ in.) that sits on the outside of the meter glass, held in place by an adhesive. Inside the box is a lens, a photocell, and a light source. When the meter—a voltmeter or ammeter, for instance—comes into operation, and its pointer moves across the dial, it eventually reaches the spot at which the unit is attached—the desired control point. Then, light to the cell is cut off, and a signal is generated which will activate a control system.



As Sealey points out, the same result can be accomplished by building special electrical contacts into the meter itself. But the new device is much more flexible and may be used with any one of several instruments—pen recorders, and dial-type thermometers, and flying-spot galvanometers, as well as conventional meters. Two detector heads, one placed at the upper and the other at the lower allowable limit, may be connected to form a simple "on-off" control.

Development price for the detector head is about $14, with amplifier at $65, and power supply at $56.

A portable sound-exposure monitor and recorder, similar in purpose to the radiation detectors that record the total amount of radiation exposure an individual receives, has been designed at Esso Research labs. Esso says the unit can be made in shirt-pocket size and will permit true, automatic recording of the length of time an individual is exposed to sound above a given level.

The sound level recorder is a transistorized device which converts acoustical signals to an electrical current that is fed to an ampere-hour meter.

The meter itself is unusual in design. Mercury-filled capillary tubing is used for the anode and cathode, the two being separated by a small liquid electrolyte gap. The flow of current transfers mercury across the gap. In this way, the gap is moved along the tube, providing a permanent, additive record of the total time during which sound above a preset level has been received. Esso Researchers say the

device is equally sensitive to pure tone and random noise; and believe it can be incorporated in a package no more than 2 by 4 by 1 in. (The original model was larger; but miniaturized prototypes are now being designed.)

• • • •

Better glass-plastic laminates are promised as a new glass fiber plant goes into production. MPI Glass Fibers, Inc (Washington, D. C. and Springfield, Va) says it's going to be able to maintain closer control of quality to minimize strength loss during processing, and plans to use a new impregnation system that will produce "a most favorable strength-weight ratio, a high modulus of elasticity, reliability and reproducibility and high temperature resistance." It will, says MPI, be "the strongest glass fiber prepreg yet to appear on the market."

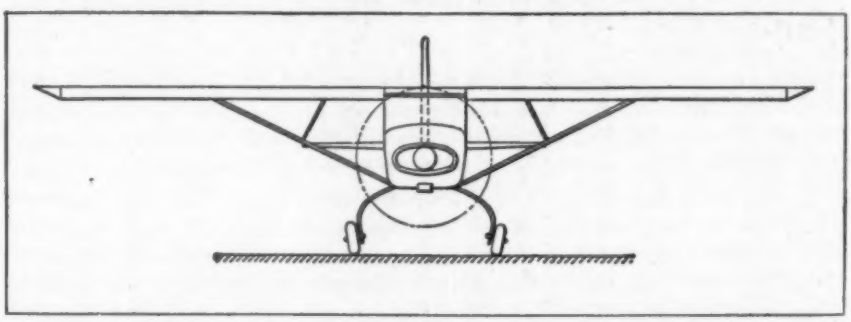
The cost? MPI admits it will be higher than that of conventional glass fibers; but says "we hope to stay in the general area of eight to nine dollars per pound initially with nominal price reductions following increased production." Initial production, though, will be aimed at such premium applications as rocket motor cases and airframe members.

A good example of the type of application at which MPI is aiming comes—quite independently—from Malmo, Sweden.

Malmo Flygindustri has designed a **reinforced plastic undercarriage for light aircraft,** and says it offers a good many advantages, not the least of which is built-in shock absorption. Preliminary tests, Malmo says "have exceeded all expectations." The aircraft rides more smoothly on the ground, and the weight saving is substantial.

Biggest problem was finding a way to attach undercarriage to fuselage. Malmo solved it by bonding reinforced plastic wedges to the undercarriage spring and then fastening the wedges to the fuselage with metal fittings.

The plane to which the undercarriage is now attached (see diagram) is also

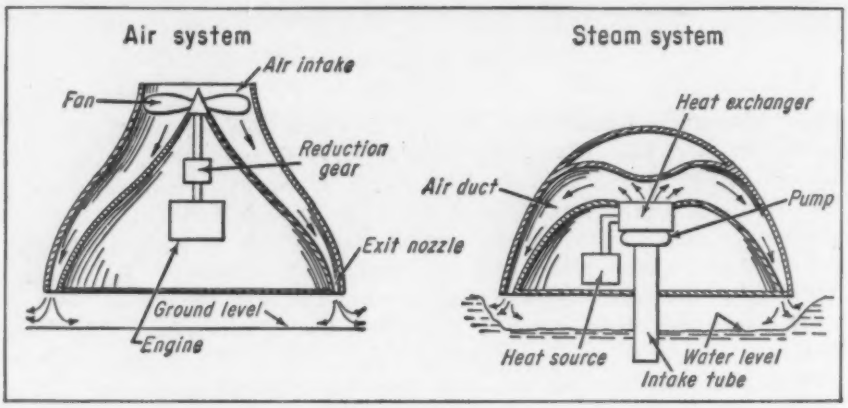


Malmo's own design, a high-wing monoplane with a 34-ft wing span and a cruising speed of about 130 mph at 60% throttle. But, says Malmo, this type of undercarriage can be used on any light and medium-sized aircraft with fixed landing gear; and might prove adaptable to ground vehicles.

A machine that rides on steam has been designed for our own Navy. It's basically a "ground-effect" unit for water-borne vehicles. But it uses steam instead of air as the working fluid—and it gets that steam by drawing water from the sea over which it moves.

In the conventional ground-effect machine, air is drawn into the machine by a fan and pumped downward through a vertical circular channel to be discharged against the surface over which the vehicle moves. This creates a high-pressure air bubble on which the vehicle can ride. The machine is fairly complicated because, an engine, with clutch and reduction units, is required for operation.

The steam machine requires neither fan nor clutch and gear. It has only a tube which extends below the surface of the water; and a pump which



brings the water up and feeds it through a heat-exchanger. When the water is vaporized, it passes downward through the channel and is ejected as a jet, just as in the air machine. R W. Pinnes, who designed the device, says a conventional heating system can be used; or a nuclear reactor might provide the steam.

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A host of new publications—some with science kits—are worth collecting.

A probability kit with a manual that alone is worth the price of admission is being readied for introduction by Science Metals Center, 59 Fourth Ave, New York 3.

The manual is a 120-page hard-bound book that's a fine review of standard deviation, χ^2, and other key statistics.

The kit itself includes an ingenious ball device called a Hectare that reproduces normal and skewed distributions, plus a build-it-yourself coin-tossing machine, a log-rolling device for studying random distribution, record charts, and scales. The price: $16.95.

Adventures in Graphing and **World of Measurement** are the latest in Webster Publishing Company's *Exploring Mathematics* series (*PE—Nov 7, p 32*). Written for young people, they're printed in good-sized type and attractively illustrated. The booklets include problems and solutions as well as descriptions and explanations, and range in length from 46 to 64 pages. Price range is 69¢ (for *Topology*, published last year) to 85¢ for the two latest. *The World of Statistics*, one of three published earlier this year, is also 85¢. *Shortcuts in Computing* 75¢; *Computing Devices*, 80¢. Earlier titles include *Fun with Mathematics*, 75¢; *Numeration Systems*, 80¢; *Numbered Patterns*, 75¢.

You can get yourself a photocell—complete with a pocket-sized handbook that will help in setting up solar amplifier and relay demonstrations, at prices ranging from $1.50 (for a selenium photocell and sun battery) to $2.35 (for a cadmium sulfide light-sensitive resistor). Or, you can have the 24-page Experimenter's handbook alone to help in explanations to the nontechnical, for 50¢. International Rectifier Corp, El Segundo, Calif, developed the sample-and-manual kits to introduce its new solar and photocell series; also has a bigger (112-page) more technical *Solarcell and Photocell Handbook*, for $2.

Want a guide to atom-land? A 40-page printed glossary that's sixth in the series being prepared by American Institute of Physics is now off the press; and, as before, AIP has offered to make single copies available free of charge to PE readers on request. The glossary runs from *Absorption Coefficient* to *Weak Interaction*, covers *fission* and *fusion*, *isobars* and *isotopes* and has an excellent table of atomic particles. Address requests for *Glossary of Terms Frequently Used in Nuclear Physics* to Audrey Meyers, AIP, 335 East 45 St, N. Y. 17 —ARG

Still the will-o'-the-wisp...

Creativity: what is it?

Research groups at U Cal, U Mich, NYU and other institutions have been probing, with support from Carnegie Foundation. Here are preliminary answers.

E J TANGERMAN, editor

The opportunities of man are only limited by his imagination. But so few have imagination that there are 10,000 fiddlers to one composer . . . Research is a high-hat word that scares a lot of people. It needn't . . . It is nothing but a state of mind—a friendly welcoming attitude toward chance . . . It is the problem-solving mind as contrasted with the let-well-enough-alone mind. It is the "tomorrow" mind instead of the "yesterday" mind.

—Charles F Kettering

WHAT is creativity? We know that there are various types: Einstein vs Tchaikovsky. We know that being highly creative is different from being highly intelligent, competent, skillful. **But we don't yet know what creativity really is, or how to foster it, or what creative individuals are really like, or their proper environments, or how to distinguish them early.**

Carnegie Corporation of New York has been supporting research on these questions, summarized some answers in its July *Quarterly*.

The creative person

Three kinds of creativity have been identified by the Institute of Personality Assessment and Research (IPAR) at the University of California during the past six years. The first group is represented by novelists, essayists and poets, the second by industrial researchers, engineers, scientists and mathematicians and the third by architects. **In the first group the creation is clearly an expression of the inner states of the creator. In the second the creator acts largely to meet externally defined needs and goals. He produces a novel and appropriate product, but he adds little of himself to the result. The third form cuts across the other two in that the product is both an expression of the creator (thus very personal), and at the same time meets the demands of some external problem.**

Individuals studied by IPAR were rated as highly creative by distinguished people in their own fields. From the study, some deductions can be drawn of **creative people as people. They are fairly intelligent, but beyond this requirement, intelligence does not crucially determine the level of an individual's creativity.** Early in life, creative individuals show the skills necessary to their ultimate careers, but many creative people come to their final careers late because they have so many skills and aptitudes that they find it difficult to choose among them.

All score high on interests which might lead them to be psychologists, architects and authors. All score low on skills for purchasing agents, office workers, bankers, farmers, carpenters, policemen and morticians. **The signs are that creative talent is not very interested in small detail, in the practical and concrete, but is more concerned with the meanings, implications and symbolic equivalents of things and ideas.**

In addition to congruence of interest, creative people share the same values. Spranger described the six basic values of men as being the esthetic, economic, political, social, religious and theoretical. For all creative types, the esthetic and theoretical are strongest; the economic tends to be weakest. The surprising thing is that esthetic and theoretical are supposed to be conflicting values, yet are of nearly the same strength in all creative groups. **This suggests that creative people are able to tolerate the inner tensions created by holding conflicting values, or perhaps that they are able to resolve the conflict.**

Other findings support the hypothesis that creative individuals are more able than most to express opposite sides of their nature, to reconcile conscious and unconscious, reason and passion, rational and irrational, science and art. **All highly creative males, for example, scored high on a "femininity" test; they were more open in their feelings and emotions, more sensitively aware of themselves than others and possessed wide-ranging interests—traits which in our culture are considered feminine. On the other hand, most of them were not effeminate in manner and appearance, but instead, assertive, dominant and self-confident.** Also, they seem to have a positive preference for complexity, even for what appears as disorder. Given a series of drawings of various types, they consistently choose those that are more abstract, perhaps chaotic;

offered a choice to make mosaic patterns, the highly creative tend to employ more colors, the less-creative fewer. It seems that the less-creative person has to impose order immediately, but the more-creative sees the possibility of imposing a higher level of order.

Personality types

Jung pointed out that when you think, you either become aware of something (perceive) or come to a conclusion about something (judge). Most mathematicians, engineers and research scientists prefer the judging attitude. Among writers the preference is strongly reversed; about 80% are perceptives. Jung further subdivides perception into sense-perception—becoming aware of things directly by way of the senses, and intuitive-perception, which is indirect perception with a deeper meaning and an awareness of possibilities inherent in things. Three out of four of the general population are sense-perceptives. They concentrate on things presented to the five senses and focus their attention upon existing facts. The other one looks expectantly for a link between something present and something not yet thought of, focusing habitually upon possibilities. **Highly creative people in all fields are overwhelmingly intuitive: 93% of the writers, 90% of the engineers and scientists, 100% of the architects. This is very significant.**

As might be expected, engineers and scientists, about 70% of them, show a strong preference for thinking. Writers show an equally strong preference for feeling, and architects split almost 50-50. Among writers there are almost as many introverts as extroverts. **Among engineers and architects there is a strong leaning toward introversion (80%).**

The creative person is almost by definition not a conformist. His nonconformity lies in the realm of ideas, however, not necessarily of behavior. He is not usually emotionally unstable, sloppy, loose-jointed, Bohemian; he is simply independent. Creative people claim more than others do that their childhoods were not entirely happy. (This may be true or they may just be aware of things which others repress.) At any rate, the finding should not be interpreted by parents as meaning that they should make their children miserable in the hope of making them creative. It does mean, however, that parents should not force too much "togetherness," that they should not prevent the child from turning in on himself. Efforts to produce "well-rounded children," made often by both parents and schools, do not help creativity.

Often the creative person is not a satisfactory student. He resists group work. He may set himself goals in conflict with those set for the class. He wants to follow his own interests. The best solution is for schools to deemphasize group participation and to provide maximum opportunity for the able student to work out his own interests. Best of all is to have creative teachers. This is true in colleges and universities as well, where the tendency is to prefer "sound" students to those who may or may not prove to be truly original. One of the most highly original architects interviewed was advised by his dean in college that he had no talent for architecture!

In industry, some personnel practices are positively inimical to the creative process. **A time clock, for example, is meaningless to a truly creative person.** At times he may appear to be doing nothing at all; at others he may work 24 hours without eating or sleeping. **There is evidence too, that the practical practice**

Intuitive engineering

The "objective" engineer is also the run-of-mine one, in this author's opinion. Note parallels with research results in the preceding article.

Harry Jackson has his master's degree, has been a stress analyst (Firestone), a research engineer (Lockheed), test engineer (Solar), senior engineer on structures (ITT), has taught at three colleges, Idaho, Oregon State (3 years) and Cal Poly (7 years), and is a staff engineer at Lenkurt Electric Co. He developed a course in creative thinking at Cal Poly.

HARRY J JACKSON

THE "objective" concept of an engineer is one who can sit at a conveyor belt of data, handbooks, curves, facts and some experience, and grind out products or designs for products. He has no particular "feel" for his work, as a great painter has. In other words, place any of thousands of engineers in the chair beside the conveyor belt and you will get nearly the same designs in each case. All have been schooled in the "objectivity" of engineering so thoroughly that there is no intimation at all of their own personalities in their work. Architects are supposed to have this feel, engineers are not. Why?

The dictionary definition of "intuition" is "the knowing of something without the conscious use of reasoning." How can an engineer know or feel that his own, or another man's, design is good, adequate or sufficient, without having intimately and thoroughly analyzed each small component? Having designed a structure himself, shouldn't he know "all about it"? Shouldn't his reasoning and technical knowledge be sufficient to determine adequacy?

The answer might be yes if *all* factors in the design of a machine and its use are known. Imagine an engineer who is a specialist in vibrations, heat transfer, stress analysis, dynamics, kinematics, physics, chemistry, economics, psychology, human engineering—just to mention a few special sciences and studies. His vast knowledge and experience would permit him to know many of the *"all"* factors in the adequate design of structures. But no man is this gener-

of "brainstorming" is not particularly productive of unique ideas. In fact, the IPAR says that it appears that the group process inhibits creative thinking.

Actually, the creative person is the victim of the sharp conflict of values in our society today. We emphasize integration of the individual into the group and still try to nurture creative talent. These goals are fundamentally incompatible. As Thoreau said of the man out of step with his fellows: "He hears a different drummer. Let him step to the music which he hears, however measured or far away."

Environment

According to psychologist Morris I. Stein, too often research concentrates unduly on one or the other of the two aspects of creativity: individual or environment. First at the University of Chicago and now at NYU, Mr Stein has been studying industrial research chemists in their laboratories. Many of his findings tally with those of the IPAR. **He found that more-creative men are more autonomous and dynamic and at the same time less anxious than the less-creative. The more creative have fewer authoritarian attitudes and give greater weight to the esthetic.** Both groups assign high authority to the theoretical value and they do not differ significantly in tests of verbal intelligence.

The creative man seems to know when to be disciplined and when not. He is more likely to "play," in a sense, with things and ideas. He is willing to allow all kinds of ideas and feelings to enter his mind. Highly creative men do not attack a problem as most of us do. They tend to become part of the problem itself, sensing its forces and following its leads; thus they let the problem solve itself. The less-creative workers seem more oriented toward quick achievement; the more creative ones work more slowly at work marshaling resources, then they work quickly and certainly to a synthesis. The less-creative try to achieve the synthesis earlier, then keep checking back, retracing steps.

The creative man in industry has five roles to play: He is a scientist, a professional, an administrator, an employe and a social being, roles which sometimes conflict. Mr Stein concludes that scientific creativity can occur only in fulfillment of the scientific and professional roles. But some fulfillment of the employe and social roles is usually necessary also.

The individual must win the opportunity to be creative. He often does so by fulfilling satisfactorily at least some aspects of his employe and social roles. This makes trouble, because the social role involves acceptance of tradition, while the scientific role questions it. To be a good employe and a good social being, a creative man finds his energy drawn away from following up on ideas. The people who prove to be creative have managed to reconcile these roles.

The need for "dither"

Somewhat similar studies have been undertaken by a group at the Institute of Social Research, University of Michigan. They find that **scientists are more creative when they are slightly uncomfortable. They need to be jarred by the unexpected, forced to an unusual or creative response by a condition of intellectual uncertainty or "dither." Anxiety, on the other hand, seems to inhibit creativity. What is needed is enough uncertainty to stimulate innovation, but enough security to offset anxiety that uncertainty arouses.** Maximum creativity should thus be found in situations containing both high dither and high security.

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alist, and each of us works in one rather narrow specialty. But we design machines that involve all of the sciences. How then can the average engineer compensate for his tremendous inadequacy? By letting his intuition play more of a part in his work. Hence "intuitive engineering," a way to prevent engineers from becoming sliderule robots.

BE the machine

How do you go about letting intuition play a part in such an objective occupation as engineering? The best answer I can give is: "Instead of just designing the machine, *BE* the machine." Don't design an electrical or electronic circuit as though you were outside looking in, but get inside the circuit and be an electron running around in the components.

Of course, this sounds ridiculous, but a troubleshooter of a complex mechanical or electronic device has literally to put himself in the machine's place, and ask, "Now where would I go wrong, if I were this system?" (The "remove and replace" principle of repair is ruining the real troubleshooter's intuitive skills, for he no longer has to know his circuits and systems; he merely keeps removing and replacing components until he finds the one that's haywire. He's not a troubleshooter, he's a nut-and-bolt jockey.)

Should engineering be objective in design function so that the ultimate effect of the particular design on man is not considered? Is the machine only to fill the immediate need of the engineer and situation? This might have been OK when science and engineering were infants, and inventions were narrow, simple and limited only to the needs or uses of a few people. But the brainchildren of the modern scientist can and do have far-reaching effects, and will have even more as time goes on. Hence, another need for "intuitive thinking" about designs and inventions, so that the ultimate effect on man will be realized and discovered.

Use your subconscious

An intuitive decision or process is one that we have arrived at by letting our subconscious take over. Our subconscious has stored everything our eyes have seen, our ears have heard, and so on with the sense of smell, touch and taste. On the surface we have forgotten most of these impressions. But, if we throw a problem back into our subconscious, we will have a much more vast collection of stimuli and experience to draw upon in order to design, or decide.

To know and to understand someone, you must be that someone when he reacts to various situations. Why not project this "knowing" to an inanimate thing like a drop of water, a molecule of gas, or an electron?

The teaching problem

Tossing empirical formulas at students and having them grind out answers is the highest form of non-intuitive engineering. The student can develop absolutely no feel whatsoever for the process involved. And this attitude carries over into professional work. On the other hand, by imagining what an increment of mass will do, or a molecule, and by exposure to the results of experimental work through photographs or curves, one can relive, so to speak, the travel or experience of the experimenter or the material of the process. Such imagined experiences are much better remembered than knowledge gained by merely reading or hearing. **end**

For high-cycle machine drives

Which electric brake?

Comparison tables and charts for selecting the smallest possible brake to provide desired stopping speed and heat dissipation.

JOSEPH F PECH, chief applications engineer, Warner Electric Brake & Clutch Co, Beloit, Wis

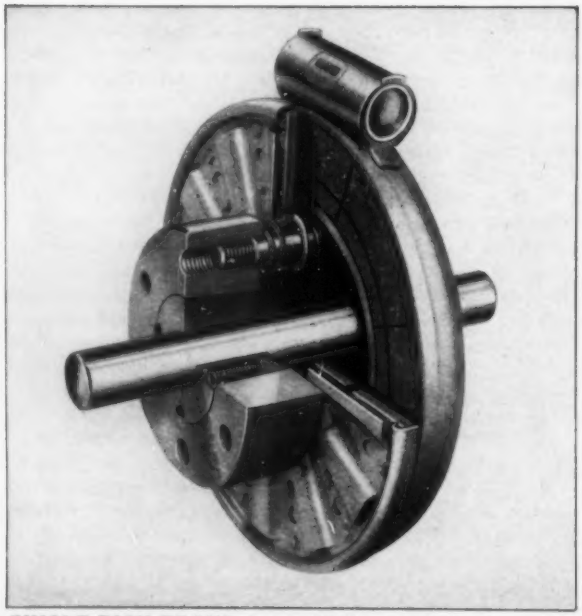
THE cumulative effect of a few seconds faster stop in each cycle can be tremendous in high-production equipment. This explains today's trend in selecting a brake for its stopping speed and controllability, rather than for its holding power. Previously, brakes functioned primarily as safety devices—now they are finding wide application as positive-control devices.

The electric brakes discussed here are positive decelerating and stopping devices—not to be confused with electrical-braking circuits, such as plug-reversing, regenerative braking, and dc dynamic braking. Four basic types are compared from a duty-cycle point of view—eddy-current, hysteresis, magnetic-particle or fluid, and electrically actuated or released friction brakes. Included is a selection procedure employing electrically actuated single-disk brakes as examples.

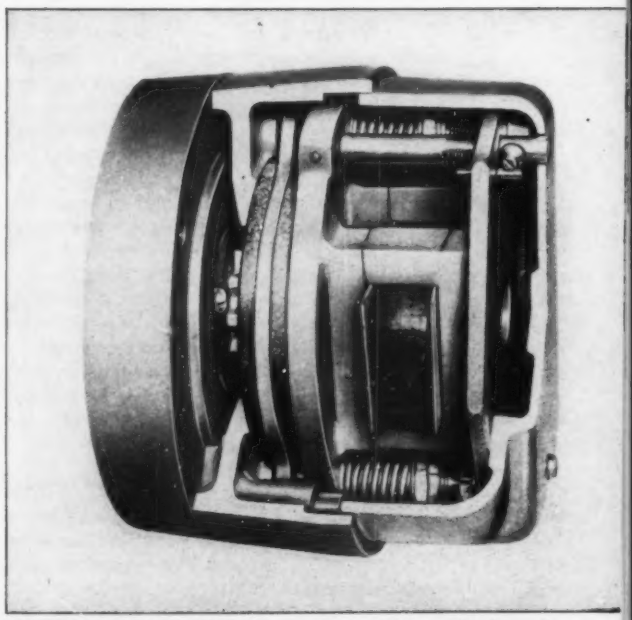
BRAKE TYPES

Where the brake is to be operated "on-off" either fully released or fully

Three electrically operated



SINGLE-DISK BRAKE, magnetically actuated
— Warner Electric.



MULTIPLE-DISK BRAKE, spring-set, solenoid released
— Dings Brakes.

engaged, as opposed to dragging or retarding in a torque-control or tensioning mode (an entirely different application), the choice is almost always a friction brake. Eddy current, hysteresis, and magnetic-particle or fluid brakes are more likely to be employed as tension brakes.

Both eddy-current and hysteresis devices are smooth operating, easy to control and nonwearing. But eddy-current brakes require some slip to develop torque—they have no holding power at zero speed. With hysteresis devices, torque is independent of speed up to high speeds, but relatively large power requirements for brake actuation limits their application to the fractional-hp range.

Magnetic-particle and fluid brakes are also smooth operating, nonwearing devices and in some designs will hold well in standstill, but they have high internal friction while idling (that is, when fully released) which generates heat and limits their thermal capacity.

Friction brakes, on the other hand, have maximum torque at zero speed, are capable of millisecond stops from high speed, and when fully released have no residual drag to generate heat. For high-cycle applications, these attributes far outweigh the primary disadvantage of friction brakes—wear in the brake linings (see Tables I and II on p 68).

Main types of friction brakes are shoe brakes and disk brakes. Shoe brakes are usually spring set and electrically released. That is, the brake shoes are continuously clamped to the brake drum or wheel by heavy coil springs and are released by energizing a solenoid to overcome the spring force so that the brake wheel (and shaft) is free to turn. Spring-loaded shoe brakes, therefore, are inherently fail-safe. Because brake torque is applied at the greatest radius possible (at the outer edge of brake wheel), shoe brakes—and their band brake cousins—have greater stopping power than most friction disk brakes of similar diameter. This makes shoe brakes good emergency brakes for heavy loads.

Drawbacks of shoe brakes are the extra space needed around the brake wheel to accommodate the operating mechanism and, for high-cycle applications, the mechanism itself. Frequent adjustments or repairs are needed to compensate for wear. Also, shoe brakes contribute a higher inertia to the drive than do disk brakes.

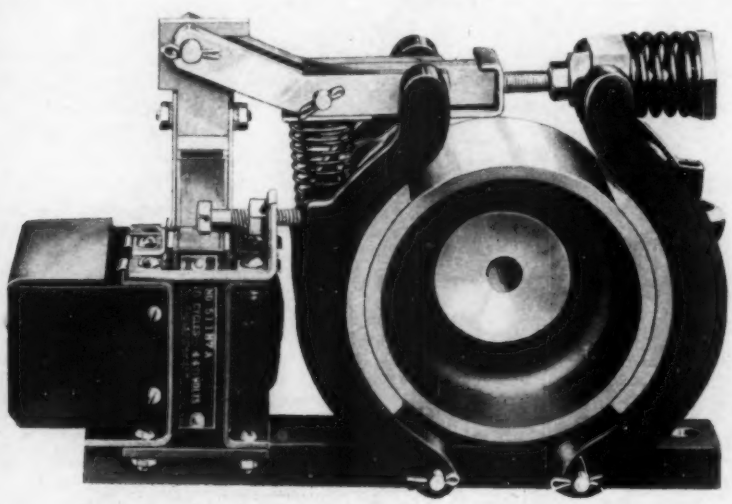
Disk brakes are best for duty cycles requiring a number of stops per minute. They are of single-disk or multiple-disk design, and have spring-set (electrically released), or electrically set operating modes (see illustration on facing page). Multiple-disk brakes have two or more stationary disks interleaved with one or more disks attached to the rotating shaft and separated by friction disks. Braking is accomplished by compressing the stack of disks in an axial direction by applied electromechanical or electromagnetic forces. These brakes develop higher torques than single-disk brakes of the same diameter and effective pressure because of greater friction surface area—but they are somewhat more limited in heat dissipation capability than single-disk brakes. Also, with single-disk brakes it is considerably easier to provide automatic wear compensation to maintain a fixed gap between the stationary and rotating members when brake is released. Without compensation, the gap widens with wear and brake pickup time is lengthened.

Where the disk brake must act as a fail-safe or emergency brake, as in elevators and hoists, it is spring-set and electrically released. Such brakes are either solenoid-operated or direct-acting. In the direct-acting, electromagnets retract the spring pressure mechanism; in the solenoid types, a solenoid does the actual retraction. With electrically released brakes, torque (and consequently total stopping time) depends on the spring setting and cannot be varied except by mechanical adjustment.

Electrically set brakes are generally direct-acting. Stopping is accomplished by energizing a stationary magnetic field coil to attract a rotating armature disk against a friction surface on the magnet. The primary advantage of an electrically set brake is that both the braking torque and stopping time can be controlled by potentiometer adjustment of current flow through the brake coil. The brake can be precisely adjusted for a given stopping time without over-torquing, and the stopping time can be quickly changed for different stopping cycles.

Where fail-safety is not an absolute requirement, the electrically set brake is generally preferred for its control precision and flexibility. The single-disk version is widely applied because it can be automatically compensated for wear (by a counter-balancing spring arrangement which maintains a fixed gap) so pickup characteristic remains constant. It can dissipate considerable heat to the atmosphere without auxiliary cooling because of its high surface-area-to-weight ratio and

friction brakes



SHOE BRAKE, spring-set, solenoid released

— Cutler-Hammer.

TABLE I.. Performance characteristics

BRAKE TYPE	OPERATIONAL MODE		DESIGN CHARACTERISTICS				
	ON-OFF	CONTINUOUS	TORQUE ADJUSTMENT	TORQUE-CONTROL RANGE	WEAR ADJUSTMENT	RESIDUAL DRAG	HEAT DISSIPATION
Magnetic Particle	yes	yes	electrical	wide	nonwearing	high	limited
Eddy current, air cooled	yes	yes	electrical	wide	nonwearing	moderate to low	good
Eddy current, water cooled	yes	yes	electrical	wide	nonwearing	high to moderate	excellent
Single-disk friction, electrically actuated	yes	yes	electrical	wide	self-compensating	none	excellent
Multi-disk friction, electrically actuated, direct acting	yes	no	electrical	moderate	mechanical	low	limited
Multi-disk friction, electrically actuated, indirect acting	yes	no	mechanical	limited	mechanical	low	limited
Multi-disk friction, spring actuated	yes	no	mechanical	limited	mechanical	low	limited
Shoe brake, spring actuated	yes	no	mechanical	limited	mechanical	none	good

TABLE II.. Representative range of ratings

BRAKE TYPE		HP	TORQUE, MAX, LB-FT
MAGNETIC PARTICLE BRAKES		1/50 to 25	0.6 to 150
EDDY CURRENT BRAKES	air cooled	3/4 to 75	5 to 1740
	water cooled	40 to 800	130 to 4600
FRICTION DISK BRAKES	single disk, electrically actuated	1/50 to 200	0.17 to 700
	multiple disk, electrically actuated	1/4 to 2000	3 to 15,000
	multiple disk, spring actuated	1/4 to 2000	4 to 7500
SHOE BRAKES, SPRING ACTUATED		1 to 2500	3 to 10,000

the direct exposure to cool ambient air of its rotating member.

BRAKE SIZE

Time, operating temperature and torque are key factors in selecting an electric brake for fast or repeated controlled stops. For the typical electric brake application, as for example a loaded conveyor, the brake can be selected almost entirely on the basis of required horsepower and speed of rotation by employing the fundamental torque-horsepower-speed equation, Eq (1) in the box on page 71.

For high-cycle machine applications, however, where driven members may be stopped repeatedly in as

# of electric brakes

BRAKE FUNCTIONS PERFORMED

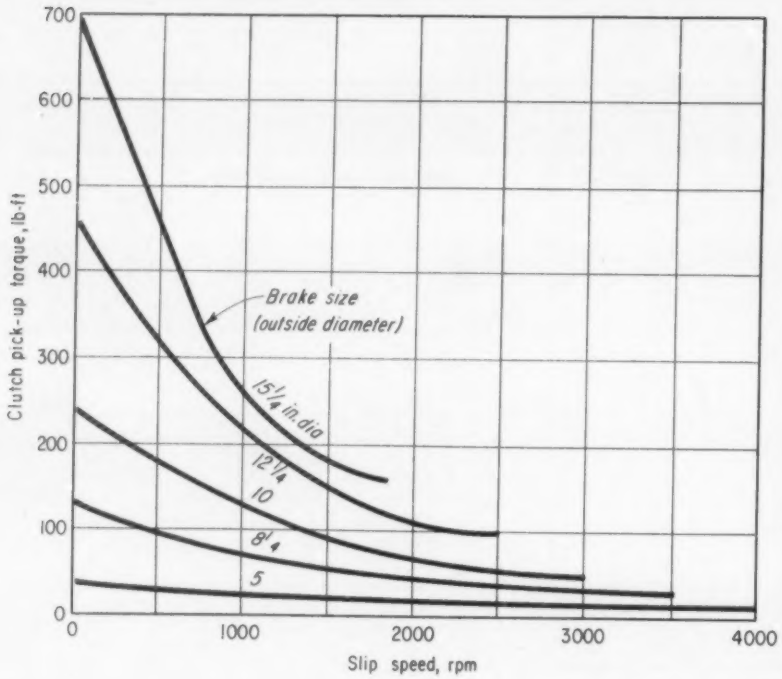
IN-STANT STOP	CUSH-IONED STOP	RETARD (DRAG)	HOLD	FAIL-SAFE BRAKE	ON-OFF DUTY-CYCLING CAPABILITY
no	yes	yes	yes	no	limited by heat-dissipation capability to low inertia loads
no	yes	yes	no	no	limited to long time cycles
no	yes	yes	no	no	limited to long time cycles
yes	yes	yes	yes	no	excellent — up to several hundred stops/min
yes	yes	no	yes	no	same as comparable size electric motor: 12 stops/min (max)
yes	semi-soft	no	yes	no	same as comparable size electric motor: 12 stops/min (max)
yes	semi-soft	no	yes	yes	same as comparable size electric motor: 12 stops/min (max)
yes	semi-soft	no	yes	yes	generally not over 3 stops/min without derating

and dimensions for electric brakes

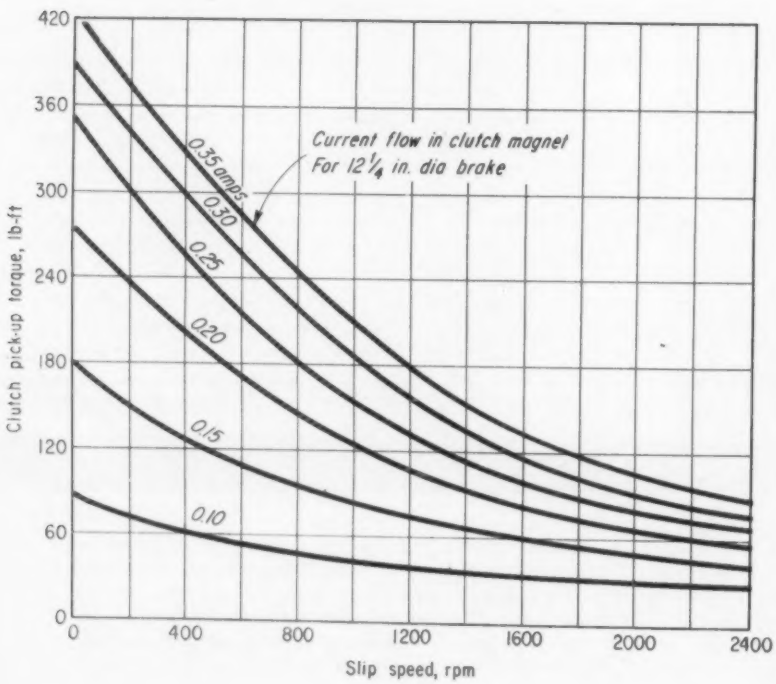
SHAFT SPEED, MAX, RPM	DIAMETER, IN.	LENGTH, IN.	INERTIA OF ROTATING MEMBER, LB-FT²
1000 to 2000	2 to 10	2 to 6	1.5×10^{-4} to 0.27
2000 to 900	6 1/2 to 24 3/4	9 1/2 to 43 1/2	0.12 to 100
1800 to 1200	14 3/4 to 36 1/2	18 1/2 to 43	8.5 to 725
10,000 to 1800	1 1/2 to 15 1/4	1 1/2 to 4 1/2	0.000125 to 3
5000 to 750	2 1/4 to 21	2 to 8	. . to 90
5000 to 1200	4 to 29	2 1/2 to 16 1/2	—
10,000 to 1200	3 to 28	4 1/2 to 12	0.023 to 485 lb-ft²

short a time as possible, selecting the proper brake involves a series of calculations and the detailed differences between various brake designs take on added significance. The function of a brake is, in essence, to convert the kinetic energy of rotation into heat and to dissipate the heat to the surrounding environment. For a high-cycle application, the brake not only must stop the load in the required time, but also must dissipate the heat generated in stopping before the next stop is made—otherwise the brake will soon burn out. Therefore, for accurate selection, inertias must be calculated and heat dissipation requirements estimated for the periods when

1 . . Torque-speed values for five brake sizes



2 . . Torque-speed for different current settings of a 12¼-in. brake



brake is engaged and disengaged. In addition, the effects of wear must be taken into account both in terms of compensating take-up adjustments and in ultimate brake life. Ease of controlling torque and pickup time also is of importance where machine flexibility is required.

Brake operating characteristics

To illustrate the basic considerations in brake selection, Warner Electric single-disk brakes are employed as examples—although the general approach shown here is applicable to all friction brakes. The design curves in Fig 1 to 6 are for direct-acting, electromagnetically operated single-disk units.

Friction-disk brakes are nonlinear devices with inverse torque-slip characteristics typified by the curves of Fig 1 and 2. These curves, generally referred to as pickup curves, are obtainable from the brake manufacturer. The curves in Fig 1 detail the nominal torque capabilities, when fully energized, of five sizes at different slip speeds (speed difference between input and output shafts). Brake torques are related to brake diameters. That is, the brake diameter determines the effective radius at which stopping torque is applied and the friction surface area of the disks. Actually, each size in Fig 1 covers a wide torque range and can be adjusted steplessly over its full range by varying the current flow through the magnet. Fig 2 shows torque-slip curves for representative current settings of a 12¼-in.-dia unit.

The curves apply to both clutches and brakes of the same size. In a brake, the armature is attached to the load and the magnet held stationary—thus, slip speed and armature rpm are the same. In a clutch, one member is attached to the input shaft (or sheave, sprocket, etc), and the other to the driven or load shaft —slip speed is then the difference between the armature rpm and the magnet rpm (or rotor rpm in the case of a stationary field clutch).

Where stopping time is not critical

Where operating time is not important, compute torque requirements from Eq (1), right, and select the smallest size unit that will develop this torque from the curves of Fig 1. A brake selected on this basis will stop the load in at least as short a time as it took a motor to bring it up to speed initially. In fact, it will take even less time because any friction in the system aids the brake whereas it opposes the motor.

Where stopping time is critical

For faster stops, select the brake on the basis of the average torque it can deliver over the stopping time interval (from the moment the brake is energized until the load is stopped) rather than the maximum torque it can develop at any particular slip speed. The average torque required to stop a given load can be calculated from Eq (2), but may not be apparent from the conventional torque-slip pickup curves. For example, superimposed on the pickup curve in Fig 3 are six curves illustrating stops made from six different initial speeds by the same brake with the same current setting and load inertia. With stops 1, 2, and 3, the brake torque builds up rapidly at first to approach the pickup curve value, and then rises more slowly along the curve as the load is being slowed to a stop. With stops 4, 5 and 6, however, the load is stopped even before the brake torque has built up its rated value.

The average torque in each case (determined by dividing the area under each curve by the rpm base) is noticeably different, and in general varies with initial slip speed according to the dashed curve. The position of the average torque curve, in turn, varies with load inertia. If the stops were made with a higher inertia load, the torque buildup preceding deceleration would be greater and the average torque consequently higher in each case. If the stops were made with a lower inertia level, deceleration would begin with less torque buildup and the average torque would be lower in each case.

For purposes of brake selection, brake manufacturers may test each design over a wide range of load-speeds and inertias to plot average torque curves such as shown in Fig 4 for a 12¼-in.-dia unit. From such curves, it is a simple matter to check whether a given brake will stop the load in a specified time.

Example—Stop a load of 20 lb-ft² inertia (including brake armature inertia) from 1800 rpm in (a) 1.8 sec (b) 1.0 sec and (c) 0.8 sec.

From Eq (2), the average torque required is

(a) $T_{av} = \dfrac{(20)(1800)}{(308)(1.8)} = 65$ lb-ft

(b) $T_{av} = 117$ lb-ft

(c) $T_{av} = 148$ lb-ft

Stop (b) falls well within the capability of the 12¼-in. diameter brake, Fig 4. Stop (c) requires a slightly higher average torque than the brake

SIX EQUATIONS FOR BRAKE SELECTION

Brake torque required for stopping load from a specified initial speed. Use where stopping time is not critical. Use with Fig 1 and 2:

$$T = \frac{5250PK}{n} \tag{1}$$

Brake torque (average) required to stop load in a specified time interval. Use with Fig 4:

$$T_{av} = \frac{Wk^2 n}{308t} \tag{2}$$

Heat input to be dissipated by brake. Use with Fig 6:

$$E = 1.7FWk^2\left(\frac{n}{100}\right)^2 \tag{3}$$

Brake heat dissipation capabilities under duty-cycle conditions. Use with Fig 5:

$$E_q = \left(E_r \frac{t_r}{t_t}\right) + \left(E_s \frac{t_s}{t_t}\right) \tag{4}$$

Equivalent inertia referred to brake armature rpm.

$$\text{Equivalent } Wk_1^2 = Wk_2^2\left(\frac{n_2}{n_1}\right)^2 \tag{5}$$

Revolutions to stop during braking interval

$$\text{Revolutions to stop} = \frac{tn}{120} \tag{6}$$

SYMBOLS

where T = torque developed at initial (braking) rpm, lb-ft

T_{av} = average torque caused by inertia from engagement to full stop, lb-ft

K = service factor—ranging from 1 for a light cooling fan driven by a fhp motor to 5 or 6 for reciprocating equipment with high-peak torque. Typically, the ratio of drive pull-out torque to running torque is employed—for example, between 2 and 3 for NEMA Class B induction motors.

P = driving horsepower, hp

n = initial shaft speed before braking, rpm

t = stopping time, sec

Wk^2 = load inertia, including brake armature, lb-ft²

E = heat generated at friction surfaces, ft-lb/min

E_q = average brake heat dissipation rate, ft-lb/min

E_r = brake heat dissipation rate when armature is rotating, ft-lb/min

E_s = brake heat dissipation rate when armature is stopped, lb-ft/min

F = frequency, number of duty cycles per min

t_t = total cycle time, sec

t_r = time that armature is rotating, sec

t_s = time that armature is stopped, sec

can deliver, while stop (a) can probably be handled by a smaller brake.

Brake armature inertia can run as high as 2.5 lb-ft² on our largest units, or as low as 0.00048 lb-in² on the smallest.

Heat dissipation requirements

After selecting a brake to meet the torque requirements, check its ability to dissipate the heat generated in stopping the load. The heat comes from the kinetic energy of the load, and can be calculated by Eq (3). To determine whether the brake can actually dissipate the heat without itself overheating, check its operating temperature vs slip-speed characteristics—Fig 5 gives the heat-dissipation capabilities of five brake sizes; Fig 6 shows the operating temperature levels reached by a 12¼-in.-dia brake at various operating conditions.

In duty-cycle applications, a brake armature is rotating only part of the time at a given slip speed. The remainder of the time it is stopped, in which condition its ability to dissipate heat is considerably reduced. Therefore, it is necessary to use Eq (4) to determine the net heat dissipation capability.

Example—What will be the operating temperature of the previously selected brake on a repeating 12-sec cycle if the armature is rotating 7 sec at 1800 rpm and is stopped 5 sec during each cycle?

From Eq (3) the heat to be dissipated is:

$$E = (1.7)(20)\left(\frac{1800}{100}\right)^2(5)$$
$$= 55{,}100 \text{ ft-lb/min}$$

Assuming a maximum temperature of 250 F, the heat dissipation capability of the brake (from Fig 6) is 85,000 ft-lb/min at 1800 rpm, and 20,000 ft-lb/min when stopped. The net heat dissipation capability is:

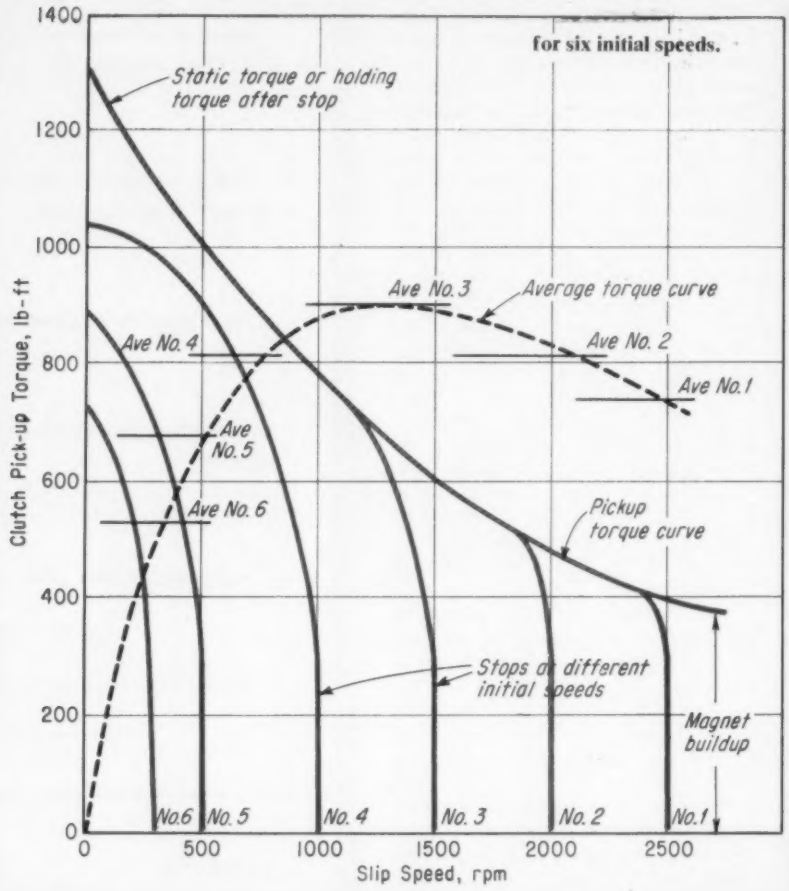
$$E_q = (85{,}000)(7/12) + (20{,}000)(5/12)$$
$$= 58{,}000 \text{ ft-lb/min.}$$

Because E_q is larger than E, the brake temperature will remain below 250 F. On the other hand, if the brake were called on to make six stops per min, allowing 6 sec at 1800 rpm and 4 sec stopped during each cycle, it could safely dissipate 60,000 ft-lb/min and the brake would run somewhat hotter than 250 F.

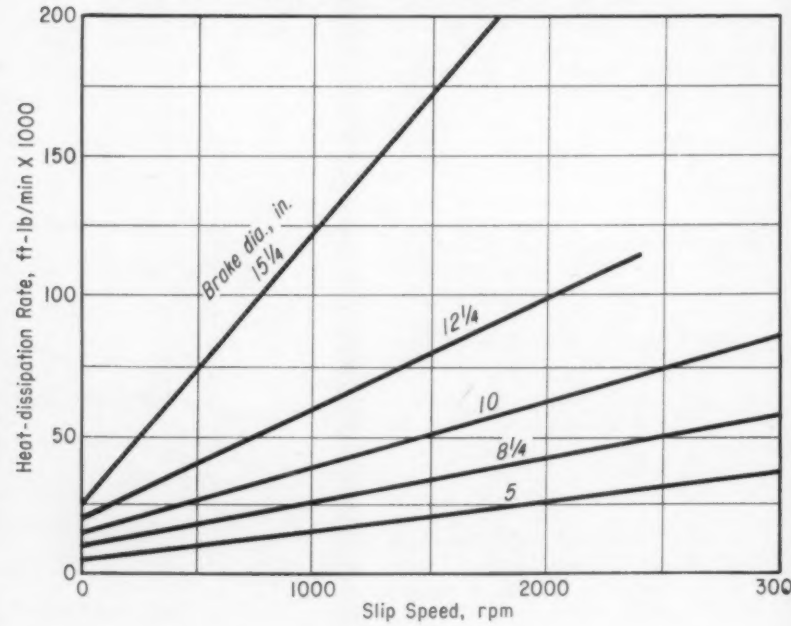
Operating temperatures above 250 F can materially affect brake life. In the 250 to 300 F range, periodic replacements are apt to be necessary, and if the calculated temperatures goes above 300 F forced-air cooling may be necessary. Often the best

text continued, page 74

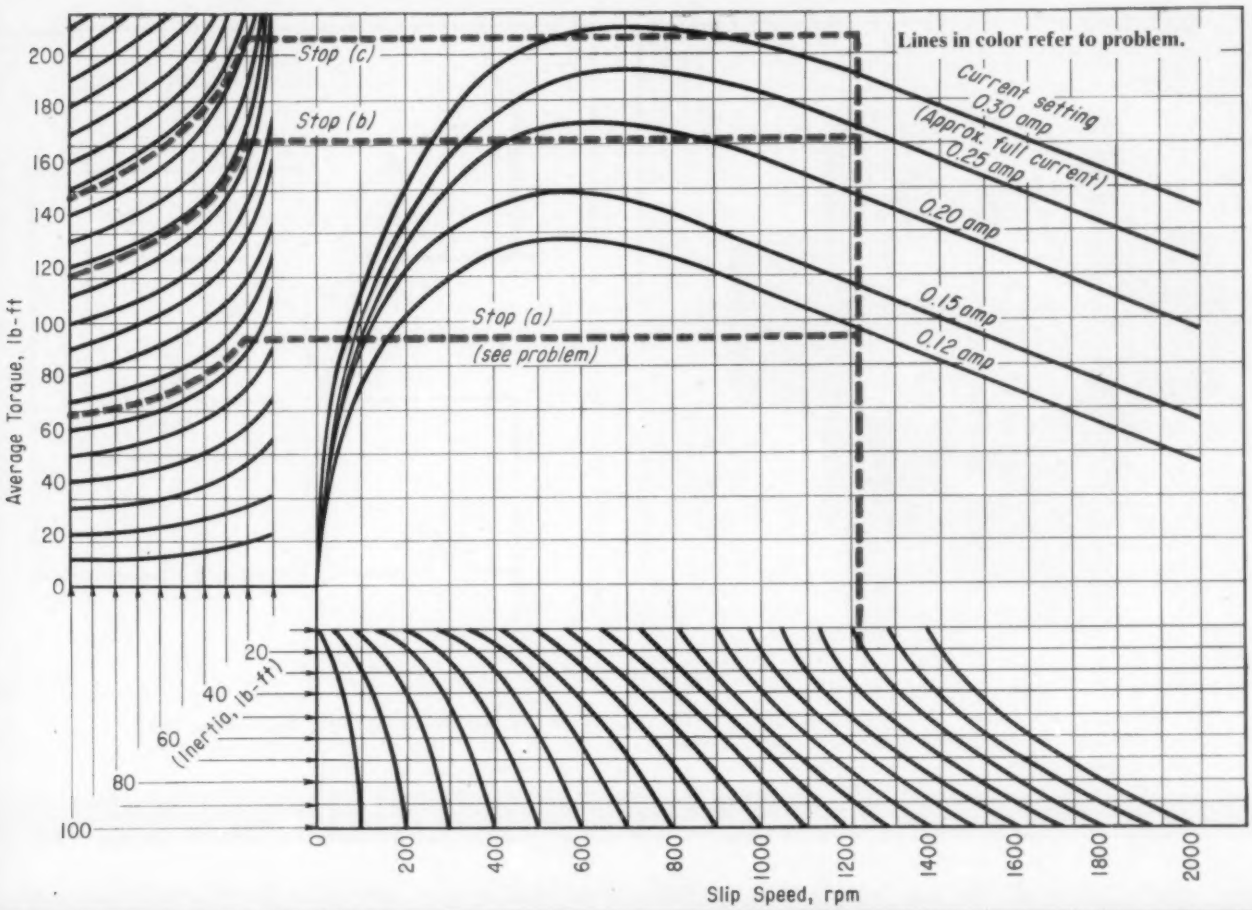
3 . . Construction of average torque curve



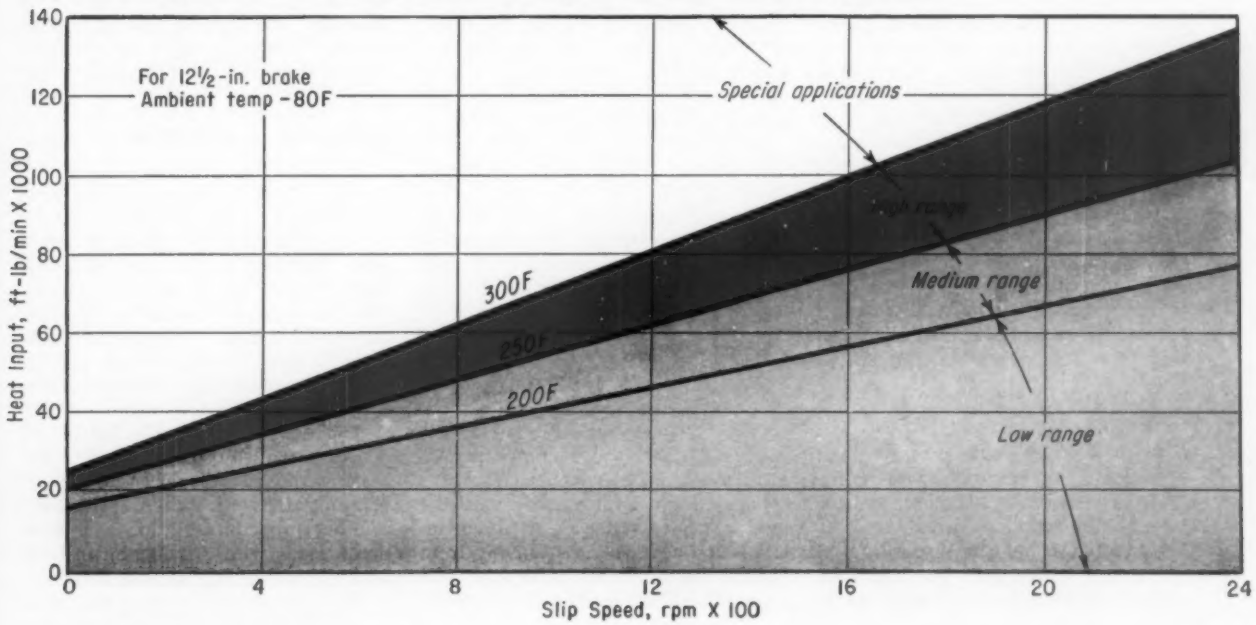
5 . . Heat dissipation capabilities



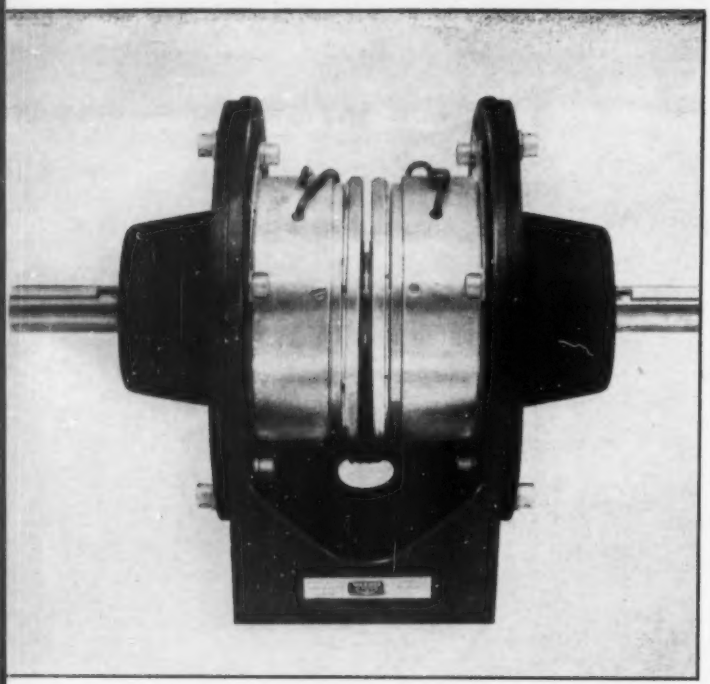
4 . . Average torque curves for 12¼-in. brake



6 . . Temperatures for heat inputs and slip speeds

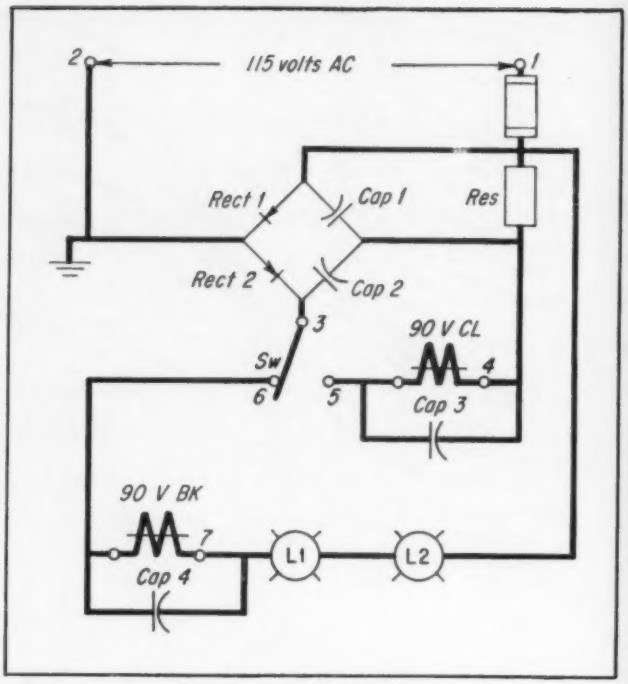


7 . . Clutch-brake package . . .



provides up to several hundred repeated stops per min with a continuously running power input – *Warner Electric.*

8 . . Overexcitation . . .



circuit for shortening magnetic flux buildup time.

solution is to use the next largest size—provided the load rpm is not beyond its capability, or the necessary control current setting so low that the range of adjustability is too restricted.

Estimating actual life of a friction device is at best a calculated guess. When the stopping interval gets extremely short, the impact of the load kinetic energy on the points of initial contact between armature and magnet friction surface (as they close together) may cause high thermal transients that momentarily melt some of the frictional material even though the brake as a whole remains cool. On the other hand, when the brake actuation time is prolonged, the continued rubbing of the armature against the magnet surface may also lead to a higher operating temperatures.

Calculating Wk^2

In calculating inertias for brake application, all inertias should be reflected to the brake armature. As per Eq (5), the reflected inertia varies as the square of the shaft speed ratio. Therefore, whenever possible, the brake is located on the highest speed shaft to minimize the total system inertia the brake must stop.

When system components are rotating at different speeds, the individual inertias are calculated, referred to the brake armature rpm and added together, including Wk^2 of the brake armature. Rather than calculate the inertia of each part in detail, it generally suffices to approximate each part by a solid or hollow cylinder or rectangular prism and then carry through the calculation on this basis. If a borderline situation results between two brake sizes, then calculate the inertias in detail—but, in general, the range of torque capability of each size is so wide that rough calculations will do the job.

Braking accuracy

In many high-cycle applications, the specified stopping interval is actually a statement of how far the brake load will travel from the moment the brake is energized (such as by actuating a limit switch) until the load comes to rest. The stopping interval can be calculated directly from Eq (6). As a rule of thumb, the load travel during the stopping interval will vary within ±20% or less on repeated stops.

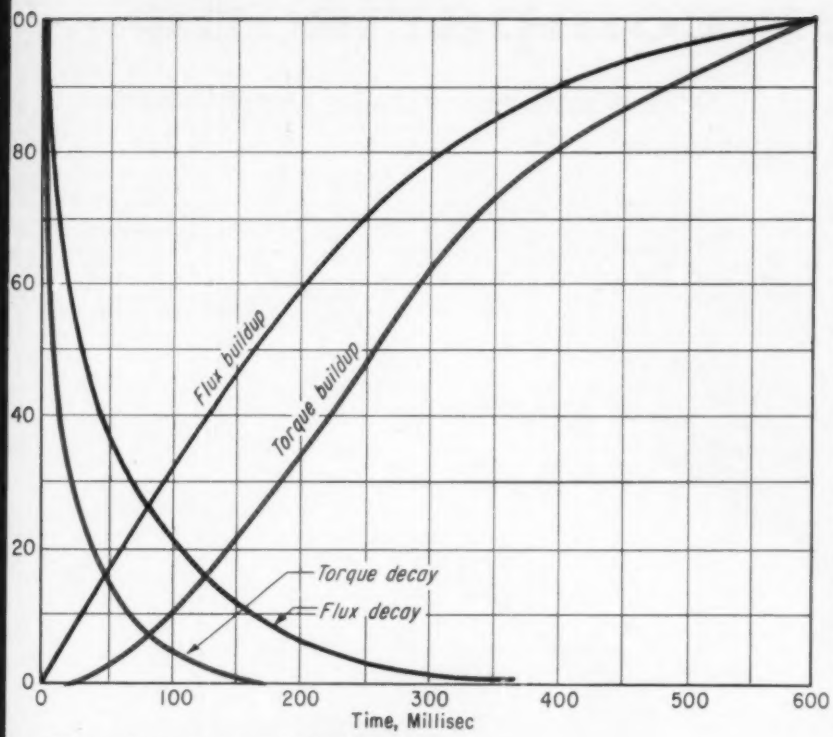
For example, the amount of load travel in stopping a 1800 rpm load in 1 sec would be 15 revolutions ±3 revolutions. If tighter control is necessary, the stopping interval can be shortened through the use of overexcitation controls to reduce the variance.

Clutch-brake combinations

In many high-cycle applications—particularly when more than 10 cpm are called for—the brake is used in combination with a similarly operated clutch, Fig 7. By releasing the clutch as the brake is energized, the drive can remain up to speed while the load is braked. When the brake is released, the clutch picks up, and so on. This avoids stopping and starting the motor and shortens the over-all cycle time. Also, because the motor is disengaged from the load before the brake is applied, there is less inertia to be stopped by the brake. The load can be stopped faster, or a smaller brake used (with a reduction in both brake armature inertia and cost).

With the motor always up to speed,

9 . . Buildup and decay . . .



of flux and torque in electrically actuated brake.

its full pull-out torque—which is substantially higher than its starting torque—is available to accelerate the load when the clutch is engaged. A flywheel is easily placed between the clutch and the motor to aid load acceleration. A smaller motor can often be substituted, and there is no danger of overheating the motor by exceeding its duty-cycle limitations—10 cpm is a typical maximum for open motors, less than 5 cpm for enclosed motors. Wear on the motor starters is also reduced.

Clutch and brake can be mounted on the same or different shafts. Generally the same size clutch and brake are used. Each has sufficient control range to make up for any differences in stopping and starting torques required. Where the clutch must accelerate a heavy friction load or perform a substantial amount of work during the acceleration period, however, a one size larger clutch may be required. On a lathe, for example, the friction loading during the period of acceleration is frequently negligible. But for a mill drive or a loaded uphill conveyor the friction load can be severe.

CONTROLLING BRAKES

One of the pimary advantages of electric brakes for high-cycle applications is that they can be electrically controlled by pushbuttons, limit switches, photo cells, relays or any other device that can act as an electric switch. Direct-acting electric brakes require direct current for their operation, but the few watts needed—less than 40 w for even the largest units—can be rectified from a 120-v ac source. Or for mobile equipment applications, brakes are built with coils that operate directly from automotive batteries.

Electric brakes are treated as inductances in circuits. This means that the current through a brake coil resists instantaneous change. Arc-suppression devices such a capacitors or diodes should be connected across electric brake terminals to provide a means of dissipating the stored energy and prevent arcing whenever the brake switch is operated.

Also, when a brake is energized, full torque is not developed immediately. Instead, as the current through are coil builds up, the magnetic flux builds up exponentially followed by the torque, Fig 9. However, when the brake is de-energized the torque falls off faster than the flux. Thus when the flux has built up to 90% of its full value, the torque is only 80% of its full value; but when upon de-energization the flux has fallen to 10% of its full value, the torque will have dropped to 1%. (Full torque is the pick-up curve value corresponding to the current setting and slip speed.) The time required for 90% flux build-up ranges from 0.055 sec for a 5-in.-dia brake to 0.350 sec for a 15¼-in. unit. Flux decay time to 10% ranges from 0.020 to 0.150 sec for the same units.

For extremely short duty cycles, the flux build-up time is considerably reduced by employing overexcitation circuits. With these, the brake when energized is subjected to a temporary over-voltage of two to six or more times its normal operating voltage, and the voltage is then reduced to normal as the flux comes up to full value. A typical overexcitation scheme using light bulbs in series with a 90-v brake coil is shown in Fig 8. When the brake switch is first closed, the light bulbs are cold and their electrical resistance is low. Consequently, almost the full output of the voltage-doubler rectifier is applied across the brake coil. Then as the light bulbs heat up, their resistance rises and the brake voltage drops to 90 v. By this method the build-up time of the 5-in. brake is reduced from 0.055 to 0.014 sec, and that of the 15¼-in. unit from 0.350 to 0.090 sec.

For **reprint** of above article, just check 641 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For more about clutch-brake and brake systems see:

How to Select Electromagnetic Clutches and Brakes for Automatic Control, Dec 19 '60, p 29—Article covers clutch-brake, duplex-clutch, double-coil clutch-brake, and triplex-clutch systems.

Realistic Ways to Speed Response of Dc Clutches and Brakes, Jan 23 '61, p 41—Shows how external circuits can reduce response time.

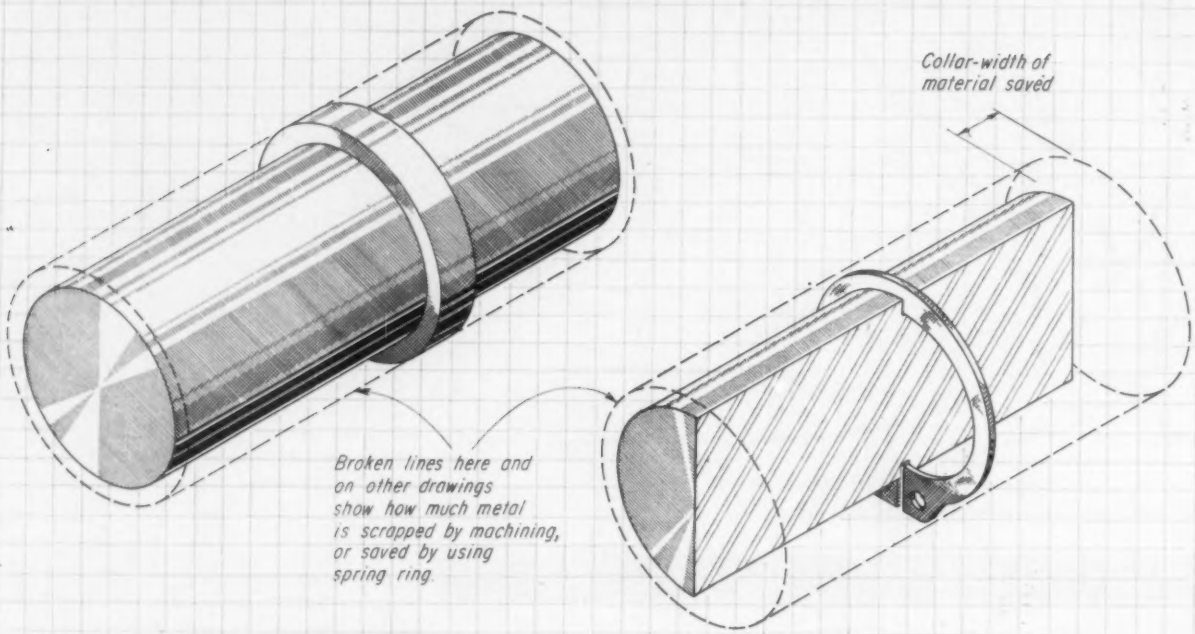
New Equations and Coefficients Speed Design of External Shoe Brakes, Nov 23 '59, p 75—External shoe brakes have high braking-torque capacity and better heat dissipation. Here is a "cook-book recipe" that reduces the usual lengthy analysis time.

Spring Clutches for Faster Response, Apr 4 '58, p 57—Article gives applications and design examples.

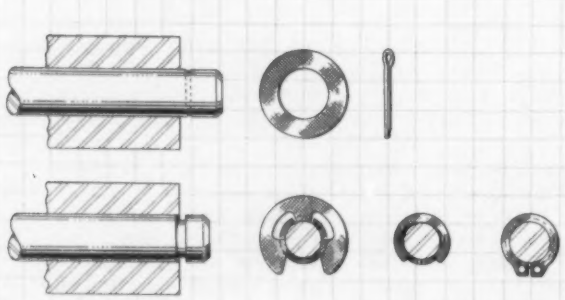
8 Fastener comparisons

A variety of basic applications show how these rings simplify design and cut costs.

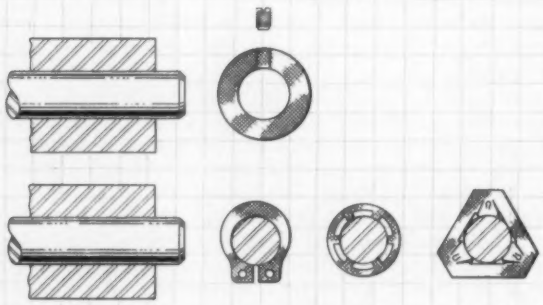
HOWARD ROBERTS, manager, engineering services, Truarc Retaining Rings Div, Waldes-Kohinoor Inc, Long Island City 1, NY


Collar-width of material saved
Broken lines here and on other drawings show how much metal is scrapped by machining, or saved by using spring ring.

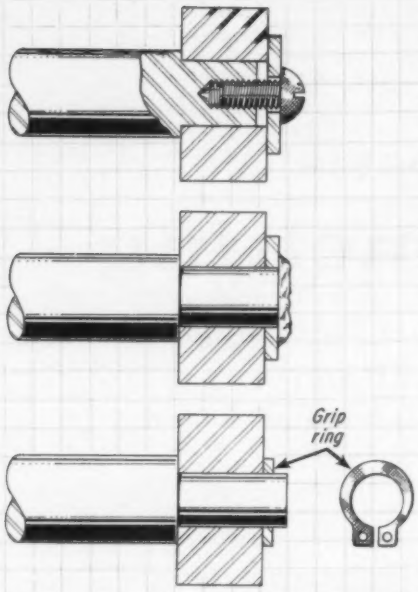
1 **MACHINED SHOULDERS** are replaced with savings in material, tools and time. Grooving for ring can be done during a cut-off, or other machining operation.



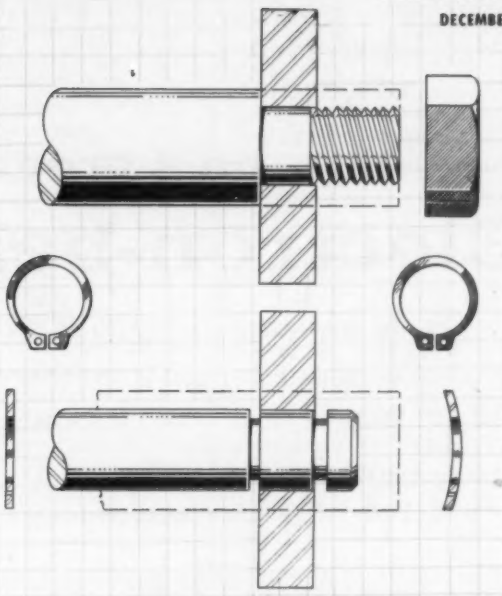
2 **RINGS THAT CAN REPLACE** cotter pin and washer are economical since only one part is required and pin-spreading operation is not needed thus cutting time and costs.



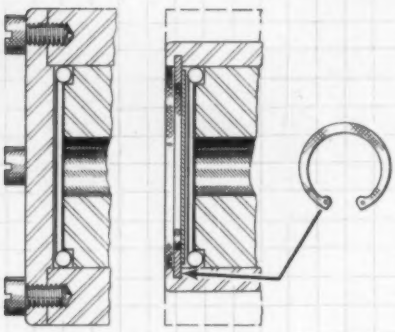
3 **WHEN COLLAR AND SETSCREW** are substituted by ring, risk of screw vibrating loose is avoided. Also, no damage to shaft by screw point occurs – a frequent cause of trouble.



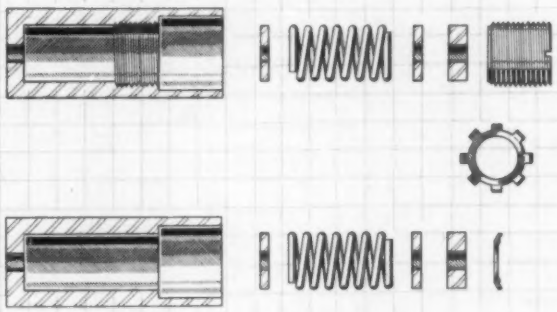
4 **RETAIN COMPONENTS** on diecastings with a simple-to-use grip ring. Slipped over the end of the shaft, the ring exerts a frictional hold against axial displacement of the shaft.



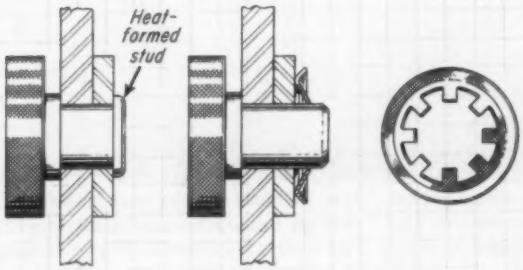
5 **SHOULDER AND NUT** are replaced by two retaining rings. A flat ring replaces the shoulder, while a bowed ring holds the component on shaft for resilient end-play take-up.



6 **COVER-PLATE ASSEMBLY** has been redesigned (lower drawing) to avoid use of screws and machined cover-plate. Much thinner wall can be used—no drilling or tapping.



7 **THREADED INTERNAL FASTENERS** are costly because of expensive internal threading operation. Simplify by substituting a self-locking retaining ring—see lower drawing.



8 **HEAT-FORMED STUD** provides a shoulder against retained parts but must be scrapped if the parts must be disassembled for service. Self-locking ring can be easily removed.

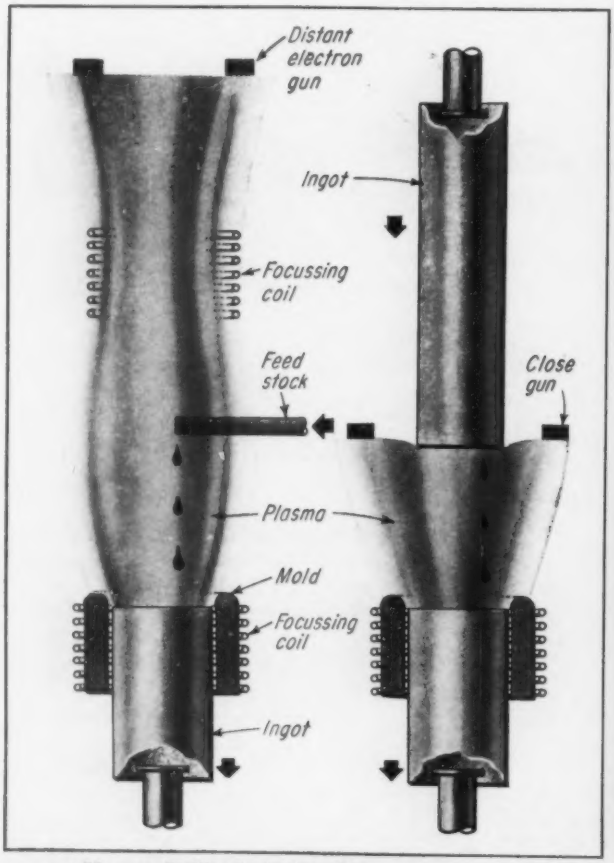
Now on a production basis

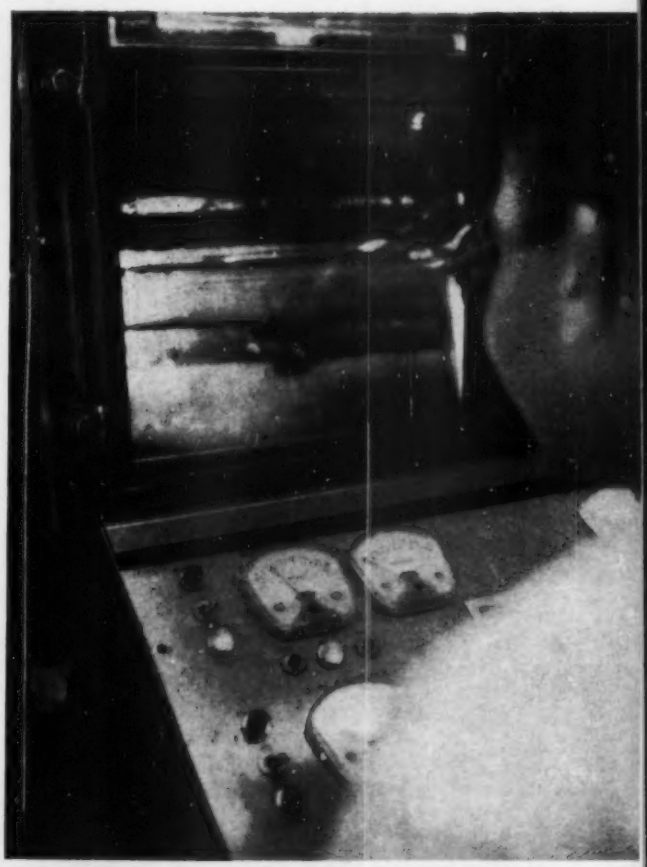
Electron-beam melting

It competes successfully with vacuum-arc or sintered powder to produce low-gas content, high-purity alloys with exceptional strength at high temperatures.

MORT SCHUSSLER, Refractory Metals Branch, Haynes Stellite Co

Electron-beam melting furnace





. . . at Haynes Stellite is designed for either side feed, for melting feed stock and scrap, or top feed for remelting ingot. To maintain the plasma, vacuum must be 0.1 micron or better, with 15,000-volt accelerating potential. Window in front of operator provides a view of the plasma and melting zone. Power supply is capable of maintaining

INCREASING need for materials with high strength at elevated temperatures is directing attention to the "refractory" metals—tungsten, molybdenum, tantalum and columbium. But all of these metals and their useful alloys combine readily with oxygen at welding or melting temperatures. Heating for welding, alloying or billet casting therefore requires effective protection from oxidation.

Powder metallurgy and vacuum melting have both been helpful in producing these metals on a laboratory or limited-production scale in forms suitable for fabrication into sheet and rod. But even the best equipment and practice has failed to deliver the full potential of some of these new alloys on a production scale—columbium, in particular.

Columbium and its alloys offer unusual promise in high-temperature applications, delivering useful strength at temperatures well above the range of any of the materials having high strength at normal temperatures. But consistent ductility needed for cold working, freedom from porosity, and weldability are all strongly influenced by mere traces of impurities—and the metal literally soaks up impurities at melting temperatures.

Electron-beam melting on a production scale (350 lb ingots, up to 6-in. dia) has solved the problem.

Purity achieved by this process gives consistent physical and mechanical properties, including good formability. Melting in the high vacuum required for establishing the plasma beam results in nearly complete removal of dissolved gases. Most other impurities are volatized by the heat and high

continued on next page

in operation...

a current of 20 amp (300 kw), but requires complex control backed up by an operator, and manual control of feed for melting stock. High vacuum removes oxygen, hydrogen and carbon; improves fabrication and weldability.

The forming methods

SINTERED POWDER

Pure metal is reduced to powder, compacted to a green bar and sintered in a high vacuum. Maximum weight of bar is about 20 lb.

CONSUMABLE-ARC VACUUM MELTING

We compact powder to form an electrode and arc melt it (at high current and low voltage) in a vacuum of 1 to 50 microns to form ingots up to 6 in. dia weighing up to 130 lb.

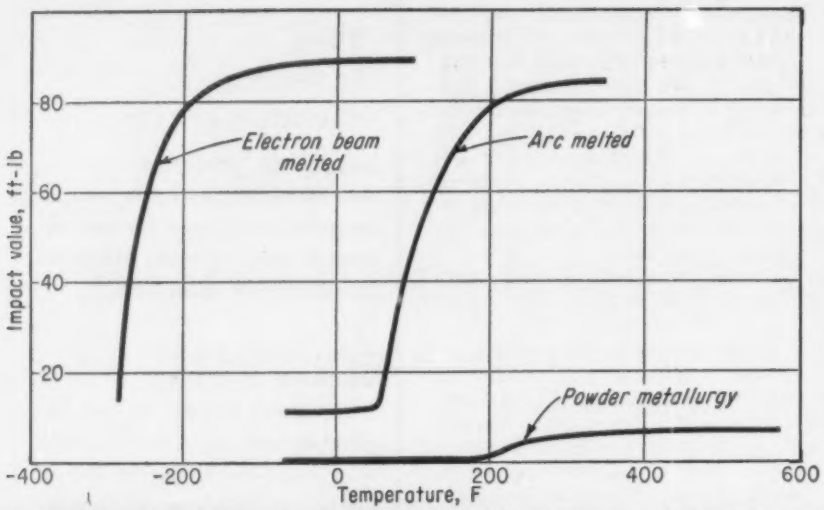
ELECTRON-BEAM MELTING

Solid ingots or compacted scrap are fed into the plasma of an electron beam in a vacuum maintained at a pressure less than 0.1 micron. The electrons are emitted from a heated tungsten filament and are driven to the melting stock at a plasma current of 20 amp at a 15,000 volt potential; metal is heated and melted by bombardment of electrons.

First melt employs a long plasma confined by a focusing coil, and feed stock in fairly compact form is inserted from the side. Molten metal drips off end of feed stock and solidifies in water-cooled mold. Ingot is withdrawn under manual control as metal solidifies.

In the second melt (to further purify the metal) the end of a previously cast ingot is lowered through a close gun into a short plasma consisting of a cloud of ionized metal. Droplets of molten metal fall into the ingot mold and solidify.

Elimination of impurities, including traces of dissolved gases, adds consistent high ductility and impact resistance, and improves welding characteristics.



Impact strength...

. . . particularly at low temperature is improved by electron-beam melting. Comparison with vacuum-arc melting and powder metal processes was made using a conventional Sonntag Universal impact machine. Tests were conducted by Westinghouse under contract to Wright Air Development Div, and reported in WADC TR 59-344 Part IV.

Materials were similar in composition, impurities and grain size; hardness for the powder-metal material was somewhat higher than the other two materials.

As shown, electron-beam melting suppresses the transition from ductile to brittle behavior to —200 F, well below any normal level.

About columbium...

Rated as the third most abundant metal in the earth's crust—exceeded only by iron and chromium —columbium has properties closely similar to iron but a much higher melting point, and excellent strength at "red" heat. For example, an electron-beam melted an alloy with 10% tungsten and 5% ziconium, Haynes alloy Cb-752, has an ultimate strength greater than 25,000 psi at a temperature of 2400 F; and the alloy retains ductility down to —150 F. It fabricates by conventional means (see "Theoretical Formability" PE—Oct. 16 '61, p 71), and welded joints are ductile. Mill products available from Haynes Stellite include sheet down to 0.020 in. thick and 24 in. wide, rod from 3 in. dia down to wire $\frac{1}{32}$ in. dia, and plate up to $\frac{5}{8}$ in. thick.

In addition to exceptional strength at elevated temperature, columbium has low neutron absorption, high ductility, and the lowest density of the refractory metals.

Room-temperature properties of refractory sheet materials

	Columbium	Tantalum	Molybdenum	Tungsten
Tensile strength, psi	40,000	50,000	90,000	150,000
Ductility, %	35	40	23	3
Density, lb/cu in.	0.310	0.601	0.369	0.697
Elastic modulus, psi x 10^{-6}	16	27	52	50
Specific heat, btu/lb/F	0.065	0.033	0.061	0.032
Thermal expansion, microin./in./F	3.95	3.62	2.84	2.45
Thermal conductivity, % of copper	14	14	34	43
Electrical conductivity, % of IACS	13	14	33	31
Neutron absorption, barns/atom	1.1	21.3	2.4	19.2

vacuum. Metal going through two electron-beam melting cycles will have interstitial impurities (oxygen, hydrogen and carbon) reduced to less than 200 parts per million, compared with concentrations of 500 ppm usual for vacuum-arc melting.

Ductility and toughness (low notch sensitivity and good impact strength) are substantially better than obtained with sintered-powder or consumable-electrode vacuum-arc melting. (See accompanying summary drawn from a recent report.)

Sounder welds are possible with E-B melted material because of lower gas content, and a transition temperature maintained well below usual service temperatures. Affinity of the metal for oxygen and nitrogen, combined with the influence of small concentrations on the transition temperature, call for highly effective protection of the surfaces during welding—a trailer shield for arc welding, a controlled atmosphere chamber, or electron-beam welding in vacuum.

Large ingots obtainable makes possible larger size of sheet or plate than possible with sintered powder, and E-B melting readily recycles and refines scrap which reduces material costs.

EDITOR'S NOTE—In addition to the PRODUCT ENGINEERING special report on "Theoretical Formability" referred to in the note "About Columbium," these earlier articles include design data on columbium.

The Refractory Metals, May 25 '59, p 43—Problems in forming and welding columbium, tantalum, molybdenum and tungsten.

Exotic Metals Seek Employment, Mar 17 '58, p 66—Comment on columbium as a structural material, along with eight others ready for use.

What Beryllium Can Do For You, Feb 20 '61, p 82—Table compares physical properties of the refractory metals and 12 others; also, a rundown on what beryllium offers in strength-weight ratio.

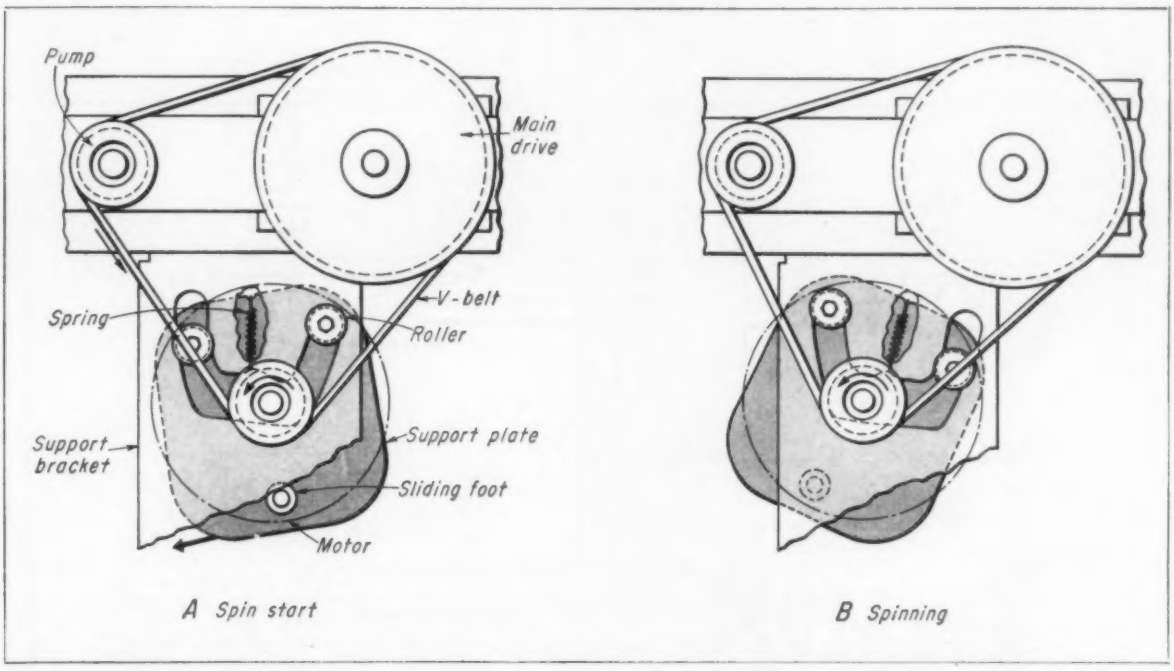
—R. W. Carson

Motor mount pivots for

Controlled tension

Belt tensioning proportional to load plus simplified access cut washing machine service costs.

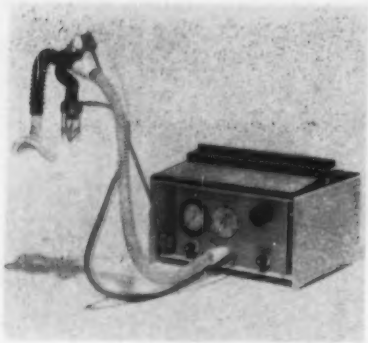
REDUCED service time and cost can best be achieved at the drawing board stage. Norge's approach was to reduce peak loads on critical components and simplify access to components subject to the most wear. A double-pivot motor mount adjusts belt tension to load and three panels provide access to the components most frequently involved in service calls. Removing the back-guard front panel and toe plate, plus opening the hinged top, permit maintenance access from the front. The 1962 household automatic washer line, consisting of four basic models, is produced by Norge Division of Borg-Warner Corp, Chicago, Ill.



DOUBLE-PIVOT drive assembly consists of the vertically mounted motor, main drive and water discharge pump. The motor pivots on either of two nylon and rubber rollers which move in a slot in the support bracket. The tension spring maintains a slight preload during idle periods to prevent the belt from jumping off the drive pulley. The main drive uses concentric drive members plus an overrunning spring clutch. When driven CW the transmission produces reciprocating motion for agitation, CCW rotation produces a high-speed spin motion.

When the agitation cycle is completed the motor is momentarily idle with the right roller bottomed in the right-hand slot. When spin-dry starts (A) the starting torque produces a reaction at the stator pivoting the motor on the bottomed roller. The motor pivots until the opposite roller bottoms in the left-hand slot. The motor now swings out until restrained by the V-belt, which drives the pump and basket.

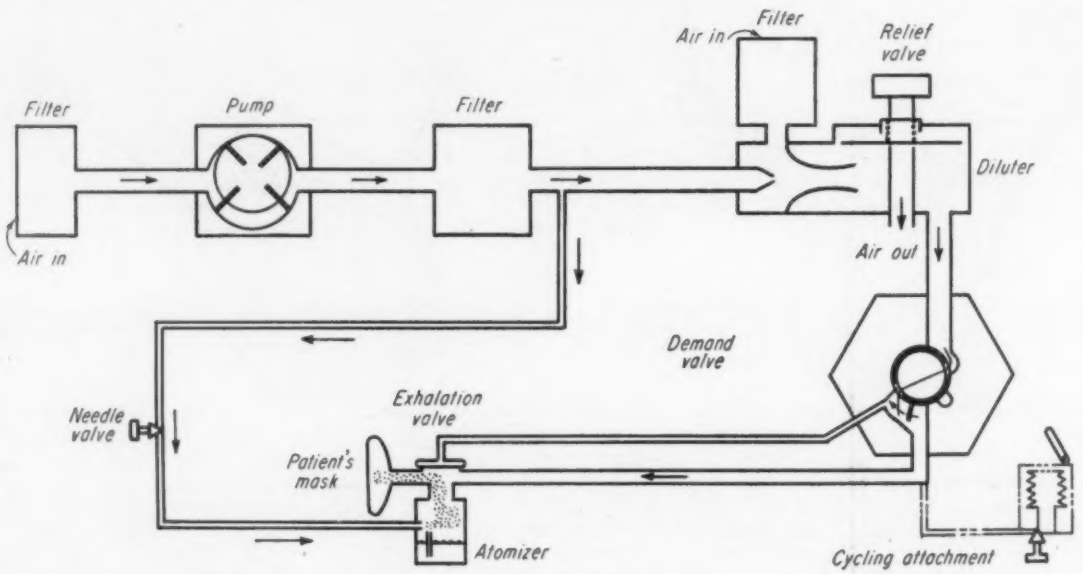
The motor, momentarily at zero rpm, develops maximum torque and begins to accelerate the load of basket, water and wash. The motor pivots (B) about the left roller increasing belt tension in proportion to the output torque. When the basket reaches maximum speed the load is reduced and belt tension relaxes. The agitation cycle produces an identical reaction in the reverse direction.



Breath controls

Pressure-sensitive valve supplies controlled pressure upon demand for mechanical respiration.

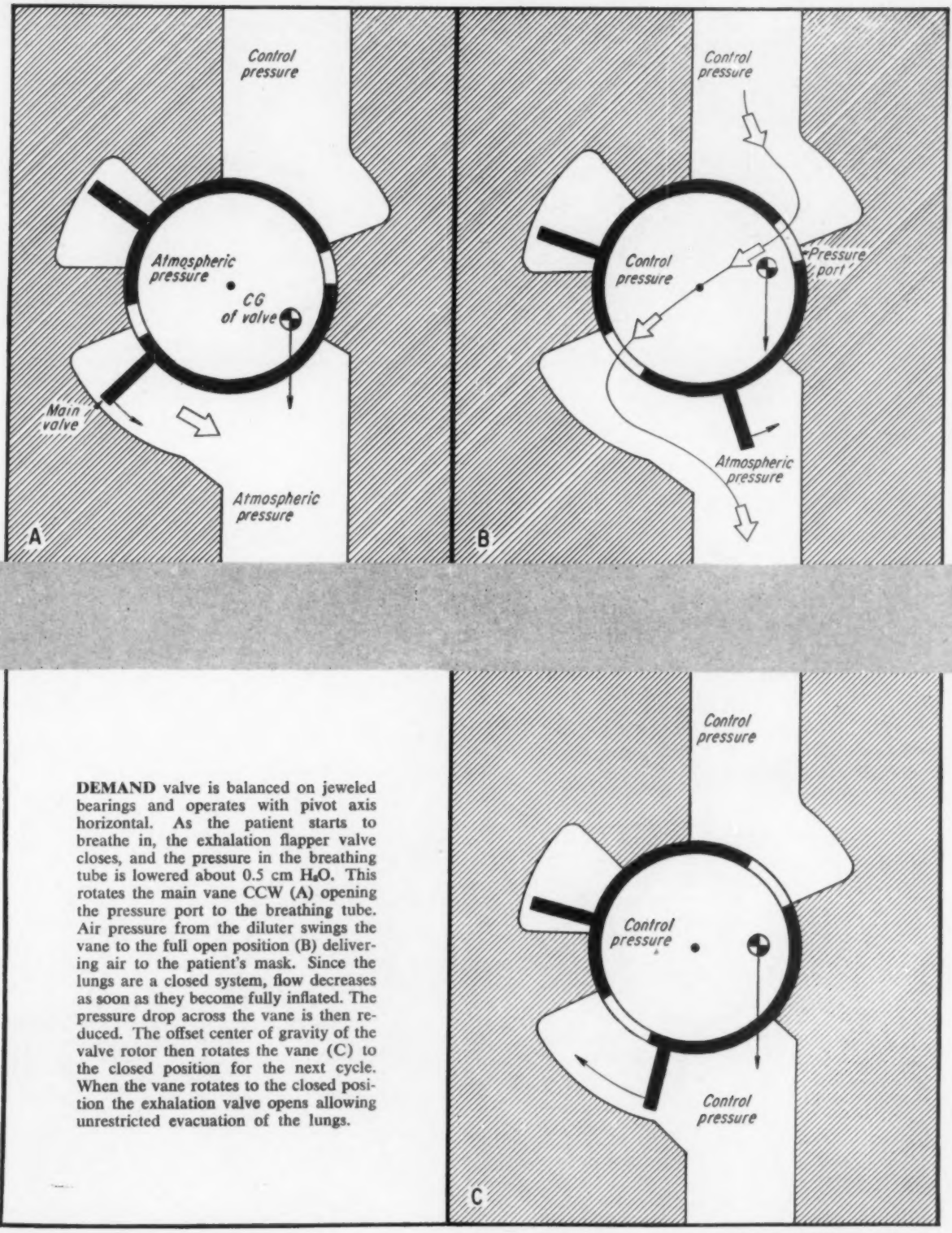
PRESSURE breathing therapy unit is used in treatment of acute or chronic pulmonary diseases to assist breathing. During inhalation the lungs are inflated by controlled air pressure, then the unit permits the lungs to deflate normally. Breathing rhythm is not automatic, being controlled by the requirements of the patient. Self contained IPPB (Intermittent Positive Pressure Breathing) unit delivers up to 90 liters of air per minute at pressure up to 0.42 psi. The Bennett Pressure Breathing Therapy Unit (Flow Sensitive) Model AP-4 is produced by Bennett Respiration Products, Inc, Santa Monica, Calif. Industrial design of the package was handled by a consultant. See details of housing and accessory design on page 84.



Compressor-powered intermittent positive pressure breathing (IPPB) units usually use a high capacity compressor to supply all of the air needed for therapy. This increases the size, weight and cost since the compressed air requires a cooling system to reduce the air temperature to ambient.

The approach taken by the designer of the AP-4 was to run the pump at a low pressure (6.5 psi), bleed some of the compressed air to an atomizer (for medication) and jet the remainder through a venturi. The jetting action entrains room air so that one part of compressed air is mixed with four parts of room air. The mixture is passed through a relief valve set at the desired pressure and delivered to the flow-sensitive demand valve. This enables the designer to use a small lightweight rotary vane pump running at constant speed and load. Since only 20% of the air to the user is compressed, no cooling system is required. The low pressure eliminates condensate removal problems.

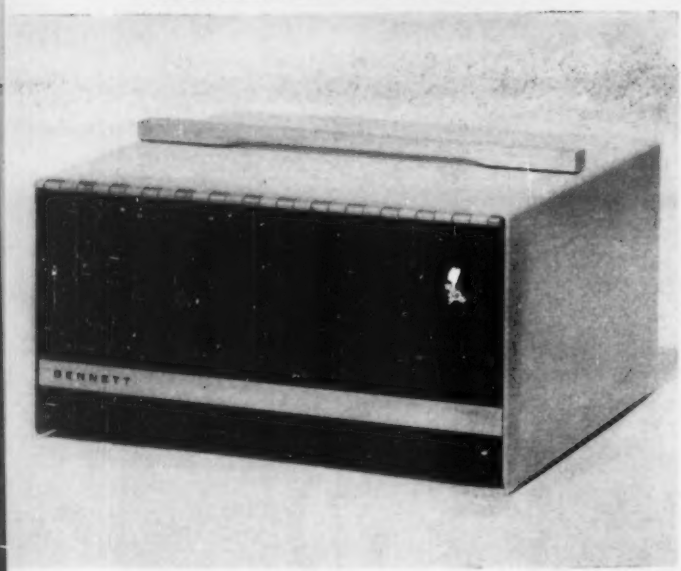
breathing aid

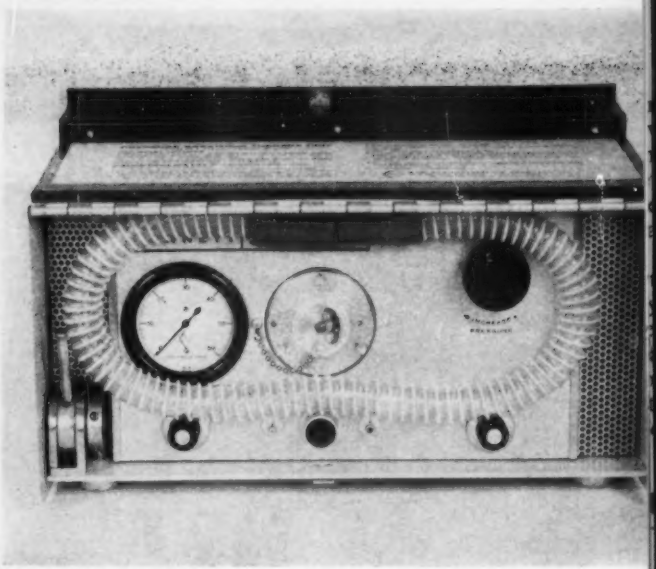


DEMAND valve is balanced on jeweled bearings and operates with pivot axis horizontal. As the patient starts to breathe in, the exhalation flapper valve closes, and the pressure in the breathing tube is lowered about 0.5 cm H_2O. This rotates the main vane CCW (A) opening the pressure port to the breathing tube. Air pressure from the diluter swings the vane to the full open position (B) delivering air to the patient's mask. Since the lungs are a closed system, flow decreases as soon as they become fully inflated. The pressure drop across the vane is then reduced. The offset center of gravity of the valve rotor then rotates the vane (C) to the closed position for the next cycle. When the vane rotates to the closed position the exhalation valve opens allowing unrestricted evacuation of the lungs.

continued on next page . . .

Breathing aid . . . *continued*





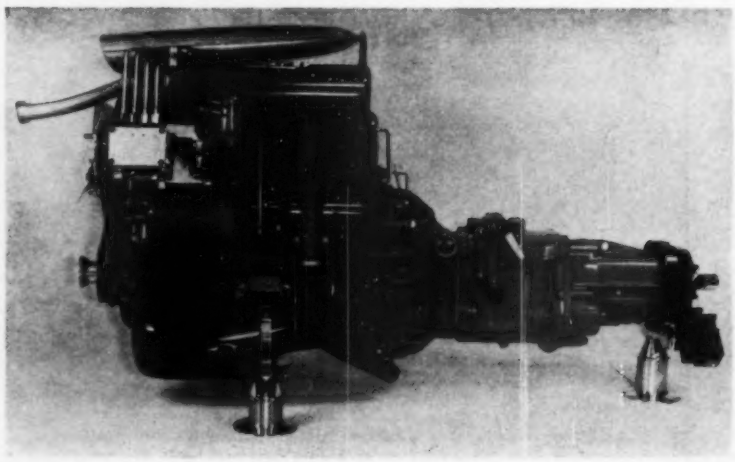
AFTER the engineering problems had been solved the producers called in Industrial Design Consultant Harvey C. Bjornlie to package the components. The goal: A compact, portable package, convenient to operate and carry.

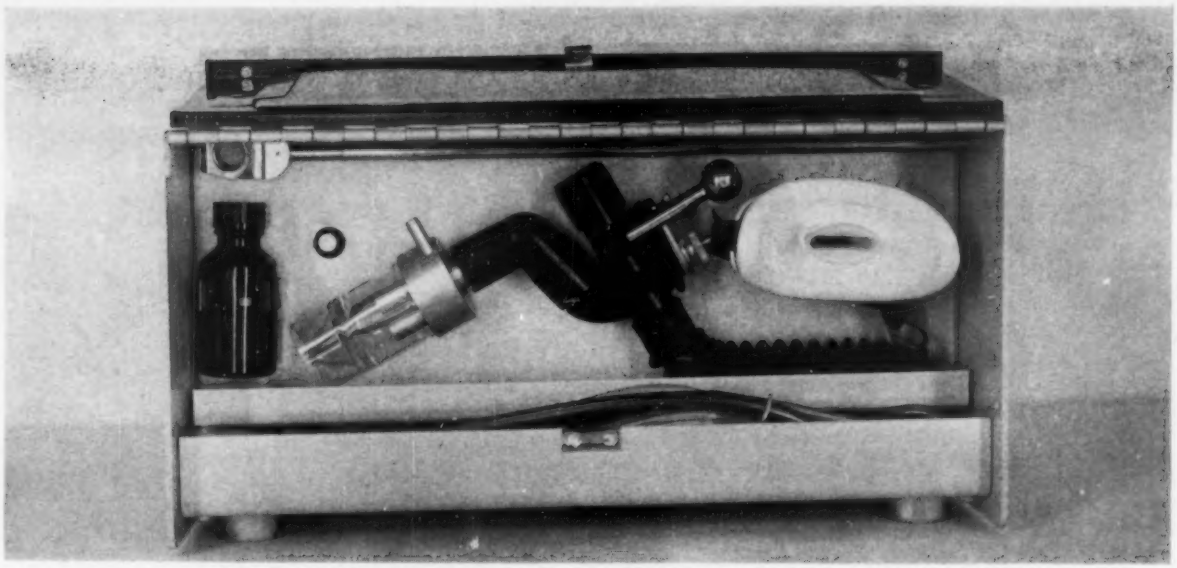
The basic package form evolved from the use of formed aluminum sheet stock. This was dictated by the low production quantities involved and the resultant simplicity of fabrication. Housing is slipped off for servicing of components by removing four screws on the baseplate. Exposed piano hinges provide 270° movement of both front and rear panels. The self-retracting handle is aluminum bar stock with a machined relief for hand comfort. Support arm, which

1 pump – 4 controls

Single plate integrates four variables to match pump output to engine fuel requirements.

INDIRECT injection system is offered as an optional accessory, develops 85 hp at 5500 rpm compared to 72 hp for the normally carbureted 1618-cc four-cylinder engine. Injectors are located in the intake manifold and operate on the intake stroke rather than directly into the cylinder during compression. Fuel injection system is installed on the Peugeot 404 convertible produced by Societé Anonyme des Automobiles Peugeot Sochaux, France.

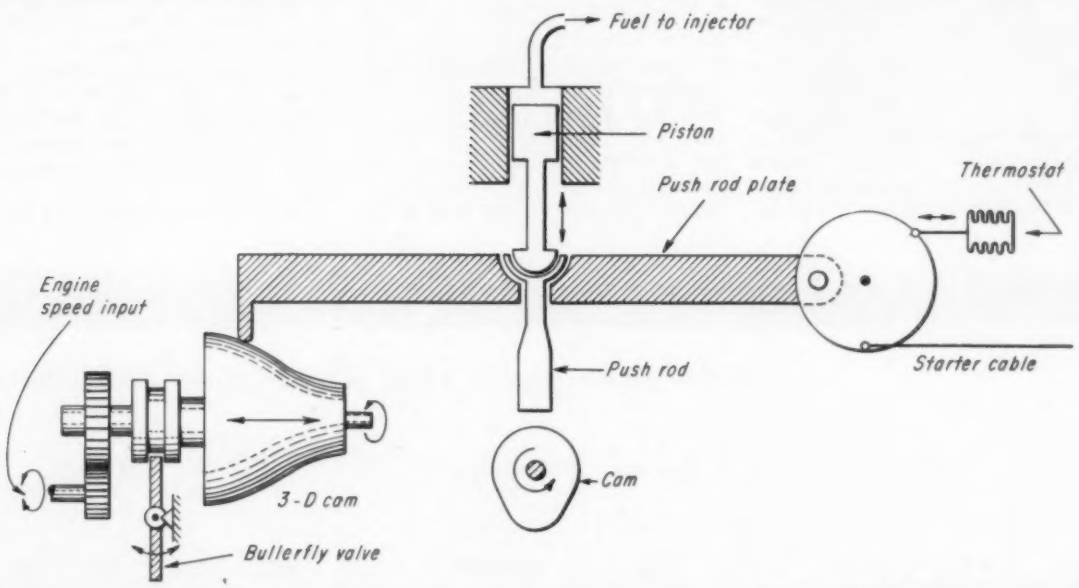




carries the weight of the hose and atomizer, telescopes like an auto aerial and rotates in a vertical plane. Frictional torque at the mount is supplied by a polypropylene disk spring loaded by belleville washers.

Lifting front panel exposes controls and indicators required for adjusting machine and monitoring its operation. Valve assembly can be removed from front panel for cleaning or servicing and all attachments are connected from this side.

All accessories normally used with the breathing therapy unit are stored in a compartment located behind the rear panel and readily accessible by unlocking and lifting piano-hinged panel out of the way.



PUSH-ROD plate is juggled by four inputs to match injection pump output to engine load-speed conditions. Pump stroke ranges from 3.2 mm for a full charge down to 1.7 mm to supply engine during variations in speed, load, temperature and during starting. Stroke starts when the engine-driven injector cam contacts the push rod. With the push-rod plate all the way down the stroke starts 30° after the intake valve opens and ends 60° later. One end of the push-rod plate rests on a 3-dimensional cam. Rotational input to the cam is produced by an eddy-current synchro whose speed is proportional to engine speed. Axial movement of the cam is produced by a linkage connected to the air-intake butterfly valve. Two inputs at the other end of the push-rod plate vary the position of the pin around which the plate pivots. The thermostat corrects for engine temperature and the starter cable lowers the plate to provide maximum injection for starting.

Gluepot problems? Take a look at

Today's film adhesives

Simple-to-apply films lower costs for adhesive joints. Bonuses include higher strength, improved reliability and closer dimensional tolerances.

E F HESS product manager, adhesives coatings and sealers div, Minnesota Mining and Mfg Co

IT is easy to see why structural film adhesives are competing for many of the jobs now assigned to liquid adhesives. In comparison with the same adhesive in liquid form, films are simpler to use, therefore lowering over-all cost of producing the bond, while giving the same strong reliable joints.

Ease of application speeds production of adhesive bonds. Films offer these production advantages:

They require no mixing. For catalyst-activated liquids, the two-part epoxies, for example, mixing is critical—resin and hardener must be in the proper proportions. If the amount of hardener is insufficient, the reaction will take too long and bonds fail if loads are applied before the adhesive cures completely. Too much hardener, on the other hand, shortens useful pot life.

Films contain no solvents. This avoids extra safety precautions required in storing the adhesive, and eliminates need for ventilation to carry away inflammable vapors from bonding areas.

Production cycle is less critical. Parts can be assembled immediately or can be stored before assembly. With liquid adhesives, joints must be kept open to allow solvents to dry before the parts are assembled. If open time is too short the entrapped solvent cannot escape and will permanently weaken the joint. If the joint is held open too long, the adhesives lose their tackiness and also lose strength.

Epoxy-base liquid adhesives contain no solvents and need no open time before bonding. They usually are bonded immediately after application.

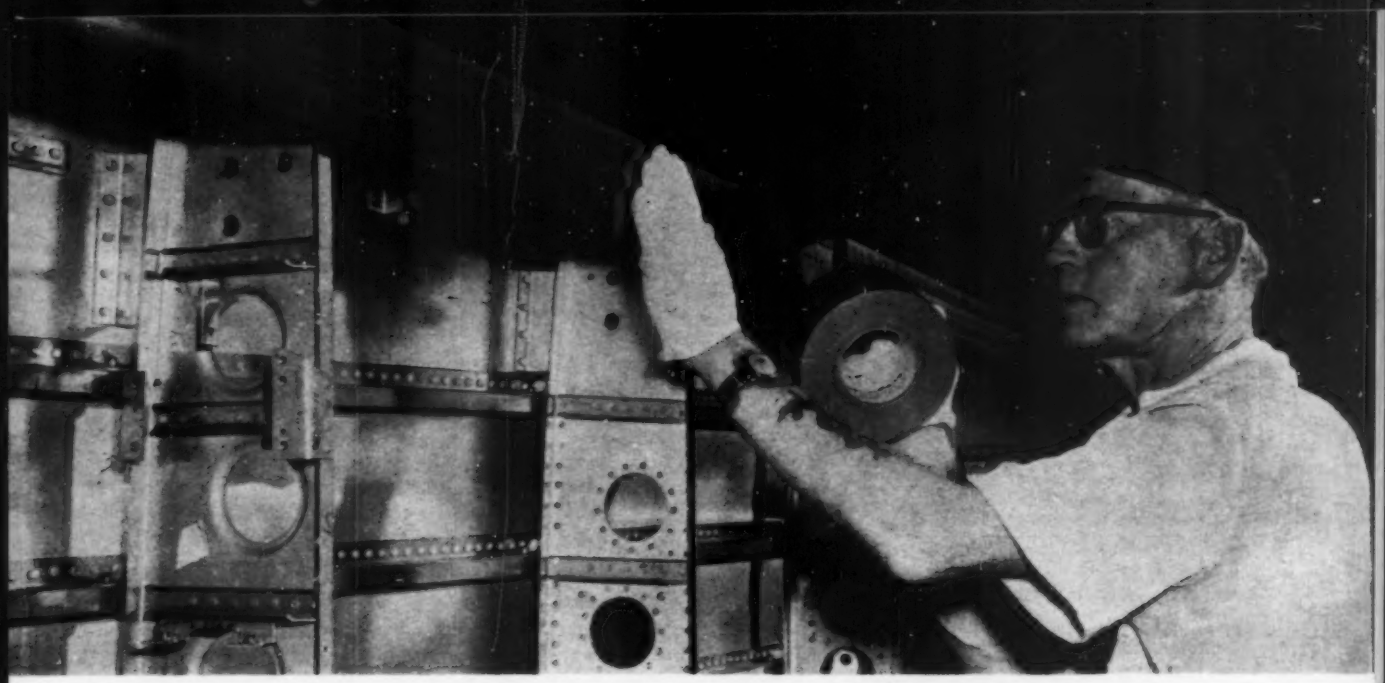
Film handling is simple. No brushing or special machines are needed to apply the adhesive evenly over large areas and parts with the adhesive applied are easier to handle because the films are not sticky or tacky.

Dry films are less hazardous. Solvents and other components in liquid adhesives can irritate the skin of people who are allergic to these chemicals. The dry films are not active until heated.

They can be limited to the bonding

How structural film adhesives compare

Adhesive type	Offers	3 M designation	Service temperature range, F	Shear strength, psi (aluminum to aluminum) at −67 F	75 F	180 F	300 F	400 F
PHENOLIC MODIFIED NITRILE	High peel strength, elevated-temperature properties	AF-10	−70 to 180	3000	3040	1750	700	470
		AF-30	−70 to 300	4000	4180	2200	1800	620
		AF-31	−70 to 400	2850	3800	2800	2100	1050
		AF-32	−70 to 250	4500	3200	2000	900	510
MODIFIED EPOXY	High shear strength, filleting properties	AF-110	−70 to 200	3700	4700	4100	350	—



UNIFORM STRENGTH OVER LARGE AREAS is ensured by film adhesive in this Convair 880 wing. While the rivets will carry the entire design load, the adhesive bond adds 25% strength and seals off wing compartments so they can used as fuel tanks. Here film adhesives are being placed on spar and wing section is shown at right going into a baking oven for the final curing bond.

area. This is especially useful in parts like manifolds where intricate passages must be kept free of any obstruction.

Strong, consistent bonds are insured because films provide optimum thickness of adhesive at the joint. With some adhesives this optimum thickness must be within a comparatively narrow range for best combination of tensile shear and peel strength.

Better dimensional accuracy is possible because films cure to a known thickness. Also, because the adhesive is not tacky, parts can be accurately positioned in relation to each other before clamping.

Less wastage further lowers cost because thickness of adhesive can be kept to a minimum. In large continuous areas, this can mean a savings of 25 to 50%. Cost savings, however, can be offset if the shape is such that large internal areas must be free of bonds. For example to bond a flange on a 12-in. pipe will waste the center portion of the film sheet unless smaller

in strength and application

Peel strength at 75 F, lb per in. width	Film thickness before cure, mils	Recommended primer	Cure for optimum properties			Remarks
			time min	temp F	pressure psi	
95 to 100	9 to 11		60	350	150	
75 to 80	9 to 11	EC-1660	60	350	150	Can be bonded at lower pressures.
55 to 60	9 to 11	EC-1459	60	350	150	Retains strength at elevated temperature.
105 to 110	9 to 11	EC-1660	60	350	150	Good flexibility, resists shock loads.
45 to 70	14 to 16	EC-1682	60	350	25	Cures at low pressures

shapes are also being bonded. An alternative is to order precut shapes from the adhesive manufacturer who may be able to plan production to utilize the remaining film—if the pieces are large.

Disadvantages of using film adhesives are that parts must mate accurately, surfaces must be relatively smooth, joint shapes essentially flat; and the materials must be able to stand heat of the curing temperatures. Also, films are handled manually.

Close fitting parts are essential. Parts should mate before clamping with a gap less than the film thickness. While liquid epoxies will fill voids up to 0.020 in. or more, film adhesive will not give uniform bond strength if pressures are not uniformly applied.

Smooth adherend surfaces are a must because the films do not have the surface-conforming characteristics of liquid adhesives. Generally, surfaces much rougher than 100 microin. are poor for film bonding. Sometimes bonding on rough surfaces may be improved by priming, but this adds the cost of an extra production step.

Flat surfaces are necessary so that films can be applied without wrinkles or bubbles. A flatness also allows pressure from clamps or fixtures to transmit pressure evenly to the bond line. When quantities are small, parts with compound curves may be bonded with films by cutting and fitting the film to conform to the surface, but this is not practical for production runs. Tongue-and-groove butt joints and cylindrical joints are not suitable for bonding with film adhesives because they require complicated fixtures to maintain the necessary pressure.

Heat must be applied to bond the parts. If materials cannot withstand bonding temperatures of 350 F, then you must use another type of structural adhesive formulated to cure at room temperature.

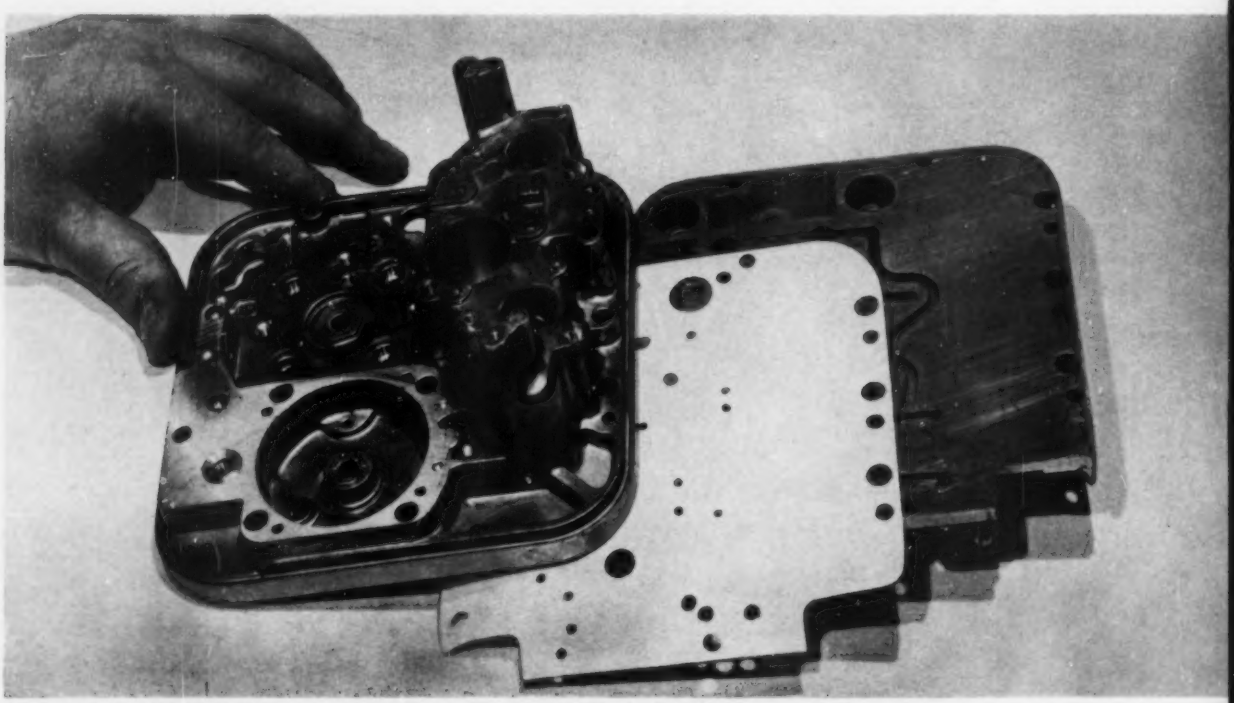
How to apply film adhesives

Adherend surfaces must be thoroughly cleaned. Cleaning procedures for film adhesives are as stringent as those for liquid adhesives. Various steps in cleaning include vapor or solvent degreasing, abrasive blasting and chemical cleaning. (For more details on cleaning cycles see: Preclean Metal and Plastics for Adhesive Bonding, *Aug* 14 '61, *p* 55.)

To position film adhesives, the paper liner is stripped off and the film slid into place. If the film must be positioned on a vertical surface it can be tacked on by heat or activated with a solvent. The simplest method is to press the film to the surface before the surface cools after oven drying—the last cleaning step. Surfaces should be 180 to 200 F for the film to stick. An alternate method is to use a sharp electrically-heated needle to tack the adhesive directly through the liner.

If the parts are not bonded immediately after cleaning, a primer should be sprayed on to keep them clean. The primers are low-solid solutions of the adhesive and will not materially reduce strength of the bond. Some magnesium alloys require primers under any circumstances.

Parts are then clamped to provide the pressure needed to contain vapors given off by volatiles during curing. If minimum pressure is not maintained during the cure the vapors will cause a porous bond with low strength. Pressure should be applied uniformly before the bond is heated. As the temperature reaches about 170 F the film softens and becomes tacky. Here the applied pressure causes some filling of surface irregularities by the adhesive. At about 200 F the adhesive flows and wets the adherends. Polymerization begins about 230 F and is complete at 350 F.



DIE-CUT FILM SHAPE seals manifold passages and assembles parts. Nitrile phenolic film limits adhesive to the bond area because it does not flow. Two nuts and bolts of carbon steel supply pressure and are left in to be painted with the assembly. In former procedure sealing was last step because paint baking temperature was too high for sealant.

The adhesives

High-strength film adhesives for structural applications are usually of two types—nitrile phenolic adhesives and the newer modified epoxies.

Nitrile phenolic films are more common because they offer low-cost bonds with exceptional resistance to deterioration from hydrocarbons and water. Their resilience gives high peel strength, even at subzero temperatures, and damping properties that lower fatigue stresses. However they have lower creep strength than epoxies, require high pressure (about 150 psi) during the bonding cure.

The modified epoxy film (AF110) has less resistance to elevated temperature than the nitrile phenolics but offers higher shear strength up to 180 F. It has good adherend wetting characteristics and will flow during bonding to form fillets. Also, no volatiles are formed during heating so bond pressures required are low. Peel strength is lower than for the nitrile phenolics although this epoxy film is formulated specifically for high peel strength. (Peel in normal epoxies is about 10 lb per in.)

Peel strength however is not considered essential if the bonded parts are both thick enough to be rigid. It is considered important if one or both of the members are thin and flexible like thin aluminum skins used in aircraft structures.

One special feature that films offer is the possibility of making up composite adhesives. These consist of a support layer with high-peel strength film on one side and a self filleting film on the other. They were developed specifically for bonding honeycomb sandwich panels but offer advantages in other applications where the two surfaces to be bonded are of dissimilar materials.

EDITOR'S NOTE: Other articles dealing with adhesives and designing joints for them:

Preclean Metals and Plastics for Adhesive Bonding, Aug. 14 '61, p 55—Gives detailed cleaning cycles for a large number of common metals and plastics.

Why Not Weld It Chemically? Feb 29 '60, p 58—Reviews bonding with structural adhesives as a high strength method for assembly of metal parts.

These Parts Carry Their Own Adhesives, Mar 2 '59, p 57—Discusses pressure sensitive adhesives; how they perform and design considerations.

Stresses in Adhesive Joints, July 7 '58, p 64—Analyzes six basic joint configurations and flow to calculate their stress concentrations.

Sandwich Panel Adhesives, May 26 '58, p 56—Compares the 14 most widely specified adhesive types.

Which Adhesive for What? Mar 17 '58, p 66. Tells what a good structural adhesive should do, compares basic types in chart form and gives a simplified shopping list.

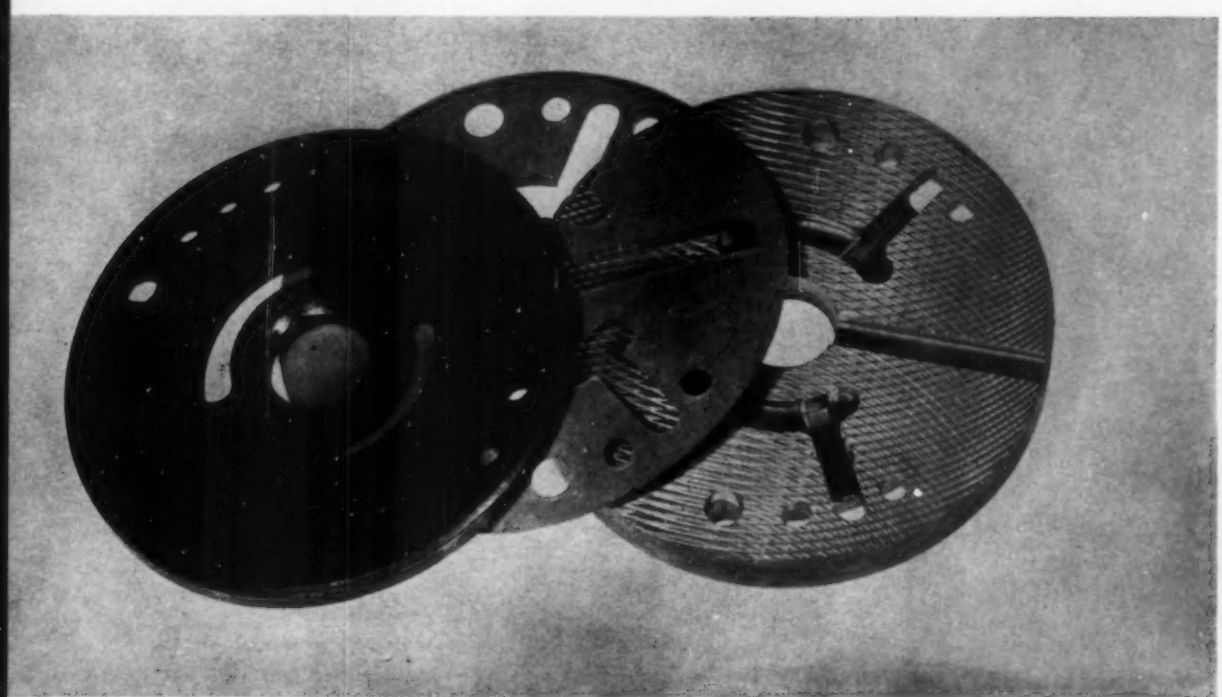
Single-component Epoxy Adhesives, May '57, p 109—Covers strength and curing data for paste adhesive requiring no hardener.

Adhesives for High-temperature Applications, Mid-Oct '58, p 25—Evaluates several types of epoxy resin adhesives under different loadings.

Adhesive-bonded Metal Joints, Jul '55, p 170—Adhesives evaluated in static and impact tests show that shear strength of lap joints are not affected by rate of loading.

Selecting Engineering Adhesives, Sep '51, p 123—Comprehensive report classifies adhesive types, gives tensile shear and impact data and supplies basic rules and joint designs for strong bonds.

—Herbert Kee



DISSIMILAR METALS—diecast aluminum and iron metal powder combine wear resistance and light weight in this inlet plate for an air-powered tool. Adhesive cost is 1.7¢ for production quantities of 35,000 per year. Metal-powder part acts as a thrust bearing surface and the aluminum diecasting channels inlet air into the rotor.

Engineers go
Laboratory

J H PRINCE, material supervisor
General Atomic Div
General Dynamics Corp.

JOHN JAY HOPKINS Laboratory for Pure and Applied Science is another California superlative — the largest and most diversified privately owned nuclear laboratory in the world.

Checkout counter also serves as receiving dock for incoming goods. Cabinets under wheel conveyor contain packing and other materials.

Speed and efficiency are principal advantages of the open stock room. Here, scientist selects pipe fittings for his particular need. Small items such as these are displayed in ordinary breadpans hooked to pegboard. As in a supermarket, he puts the hardware or raw materials in his pushcart and moves to the checkout counter when his shopping is done.

shopping in supermarket

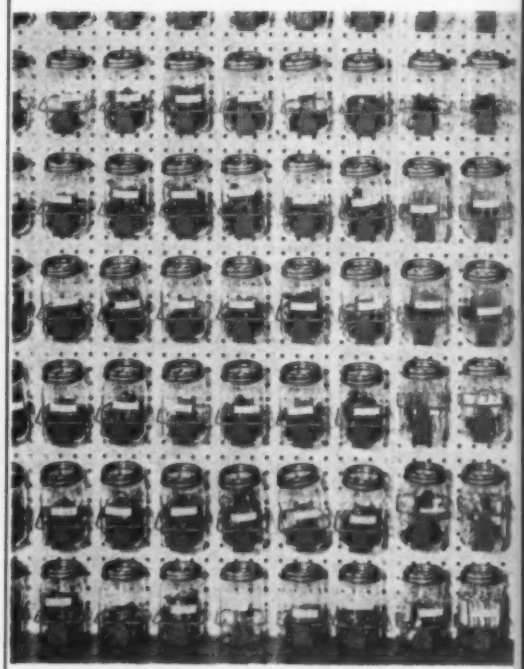
Hardware is displayed in open bins so engineers can choose exactly what they want.

Located atop San Diego's Torrey Pines Mesa (see below), the laboratory is part of the General Atomic Div, General Dynamics Corp. The arc-shape structure in center contains 150 individual laboratories—space for more than 750 scientists, engineers and technicians. Sprawling nearby is a building housing the supermarket, enclosing 12,000 sq ft of warehouse space.

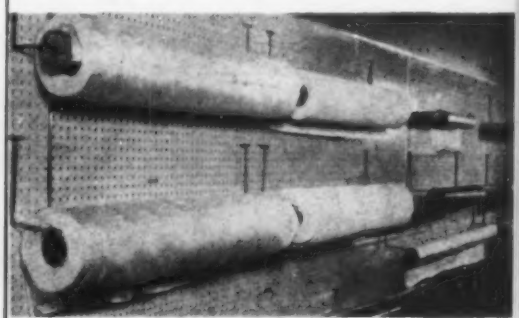
Photos by DeWayne Tappe, General Atomic Div

Other side of the pegboard is ordinary steel shelving. It is used to stock office supplies and other materials of regular size. But the pegboard backing can be used to hang things on this side too—like the breadpans at far right. Displayed this way. The stock can be checked quickly by a clerk walking down the aisle

Catalog file desk near warehouse entrance directs shoppers to any of the 9000 stock items. For reference, each aisle is coded with a number and letter; each bin is labeled and identified by code number.



Small hardware and electronic components, such as these wire-wound resistors, are stored in open-top fruit jars resting in brackets hooked to the pegboard. The glass jars make selection easy, aid stock clerks when taking inventory.



Bulk material is suspended from the pegboard too, or stored in cabinets in the end of these display racks. For rolls and tubes of variable length, there are special back-slanting shelves, which also hang from the board on similar brackets.

Higher-temperature insulation for

Overload margin in motors

Enclosed motors are now being standardized with class-B insulation to match class-A open motors in overload capacity. Here's why.

R F WOLL, design engineer, A-C Motor Engineering Dept, Westinghouse Electric Corp, Buffalo, NY

STANDARD enclosed motors are normally limited in power to the nameplate rating, yet open motors of the same physical size have 15% or more overload margin—called service factor. There is a sound engineering reason for the difference: Temperature rise is a less restrictive design limitation in an open motor than in an enclosed motor, which is mechanically protected to withstand adverse environment and abuse.

This inherent difference in dissipating capacity can be a handicap if you want complete interchangeability between motors of the same rating. (The problem is progressively less severe as motor size diminishes: The surface area available for cooling is large compared with the volume of heat-generating parts for small motors as opposed to large.)

Now there are standard enclosed motors up to about 50 hp with service factors equivalent to those on open motors of identical frame and mounting dimensions. This is important because enclosed motors (mandatory in many applications) comprise 25% of all industrial motors and it sometimes happens that an enclosed motor must replace an open type for an existing machine. For larger ratings, through about 150 hp, new designs permit application of service factor to enclosed motors built in the same frame size as previous enclosed motors without service factor.

The uprating is done with higher temperature insulation (class B instead of class A), and the motor simply is allowed to run hotter at the service factor load while maintaining normal class-A rise at rated load. Costs of class-B materials have dropped considerably within the past few years (only a few dollars more than a class-A motor, 5-hp size) and it is now feasible to offer a standard line of class-B TENV (totally-enclosed nonventilated) and TEFC (totally-enclosed fan-cooled) ac induction motors.

There are other ways to improve overload margin in a motor than by allowing it to run hotter. For example, increasing field strength of an induction motor increases load capacity. But if this method is carried to extremes, the motor will have good performance at overload but poor power factor at rated and lower loads. Another way is to increase the amount of electromagnetic material in the motor. Limitations here are cost and lack of space inside a given frame to hold larger parts. Many standard enclosed motors are already designed with the maximum practical amount of magnetic material. So, service factor is improved by using higher-temperature insulation on fairly standard parts.

What service factor does

Service factor and overload capacity are synonymous. A service factor of

Insulation temperature classifications (from AIEE)

CLASS	MAX TEMPERATURE °C	MAX TEMPERATURE °F	SUITABLE INSULATING MATERIALS
O	90	194	Past practice of classifying materials by type (epoxy, silicone, cotton, and so forth) for various temperature ranges is no longer followed, because new, improved materials are continually being developed. The modern functional method is to pre-prove (with standardized test procedures) that the insulation system as a whole is suitable for use at the specified temperature.
A	105	221	
E	120	248	
B	130	266	
F	155	311	
H	180	356	
C	220+	428+	

1.15 means that the motor can be run continuously at 115% load (15% overload) without exceeding its maximum allowable temperature.

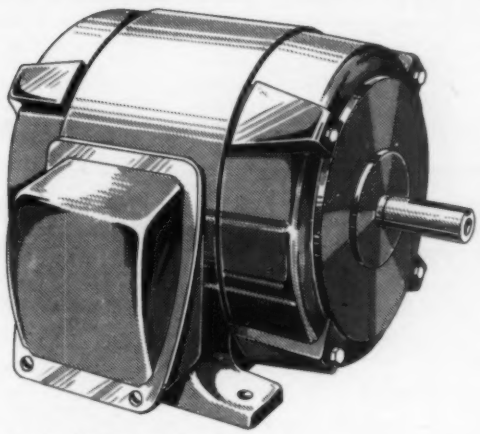
Service factor adds these benefits to a motor: increased load-carrying ability at normal ambients; cooler running and longer life (up to four times rated) at normal loads in normal ambients; and smaller physical size, on the average, for a given application need with resulting cost savings in motor, cable and mounting space. With service-factor margin available, you can plan to run the motor continuously at nameplate rating (the most efficient way to operate a motor) without fear of damage from continuous moderate overload, sporadic excessive load or line-voltage variations.

Here is an example of how service factor is determined: A standard 5-hp open motor with class-A insulation has its rating based on a 40-C temperature rise above a 40-C (104-F) ambient, measured with a thermometer. With this 40-C rise, plus the 15-C allowance for hot spots, the maximum temperature that the insulation will reach at full load is about 95 C. But class-A insulation can withstand 105 C continuously without reduction in rated life. Therefore, the motor can be safely overloaded (in this case 15%) before the real 105-C limit is reached. Small open motors (less than 1 hp) have even greater overload margins: service factors are greater than 1.20 or 1.25. But enclosed motors normally have no margin: the service factor is 1.0.

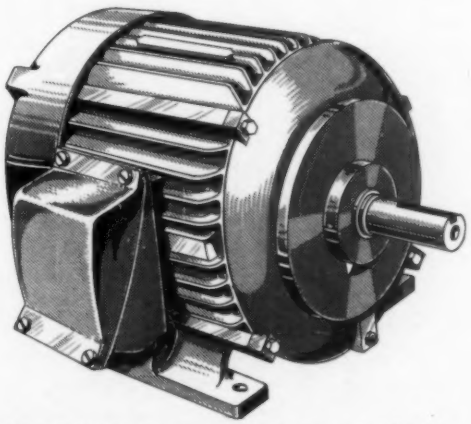
Allowable service factor is based on actual tests. In testing open motors, thermometers may be inserted on the windings. But for enclosed motors where thermometers are inconvenient to use, the motor temperature rise may be determined by measuring overall winding resistance before and after a suitably long loading period. The temperature rise by resistance will be somewhat higher than the thermometer temperature rise because the rise by resistance measures the average temperature rise of the total winding, and thus more closely approaches the true hot-spot temperature rise. Whereas, the thermometer, of necessity placed on the surface of the winding, measures a rise that is relatively lower than the hot-spot rise. There is ample information in the literature to compare the two methods—thermometer and resistance—and most test procedures carefully make a distinction between them.

Motors for higher temperature are slated for the future—five years or so away. Predicting the specific class is

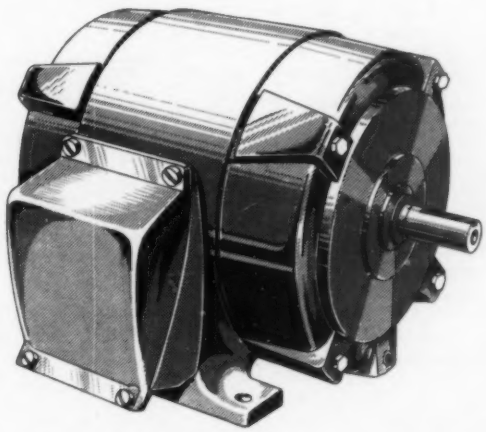
Three common induction-motor types



Open (drip-proof)



TEFC (totally-enclosed, fan-cooled)



TENV (totally-enclosed, non-ventilated)

Hp at 1.15 service factor

NORMAL HP RANGE FOR 1.0 SF (CLASS-A)	MOTOR NAMEPLATE HP	NORMAL HP RANGE FOR 1.15 SF (CLASS-B)
	50	46.0 to 57.5
40 to 50		
	40	34.5 to 46.0
30 to 40		
	30	28.75 to 34.5
25 to 30		
	25	23.0 to 28.75
20 to 25		
	20	17.25 to 23.0
15 to 20		
	15	11.5 to 17.25
10 to 15		
	10	8.6 to 11.5
7.5 to 10		
	7.5	5.75 to 8.6
5 to 7.5		
	5	3.45 to 5.75
3 to 5		
	3	2.3 to 3.45
2 to 3		
	2	1.72 to 2.3
1.5 to 2		
	1.5	1.15 to 1.72
1 to 1.5		

guesswork, but class F (155-C hot-spot temperature) has been frequently mentioned in NEMA discussions (National Electrical Manufacturers Association). Class-H insulation (180-C hot-spot temperature) has been used more frequently than class F in the past, but the motor surface and bearing temperatures can become excessive and general acceptance is unlikely.

Special-purpose motors of many types already are available with standard class-B and higher-temperature insulation. Mill motors, for example, have had class-B insulation for years to allow higher ratings in smaller frames. Other examples are industrial dc motors, encapsulated small integral-hp motors, and wound-rotor induction motors. Mining motors frequently are made with class-H insulation (180-C hot-spot temperatures), and even this insulation is overtaxed in some applications. By permitting shorter useful life, a 50-hp mine motor with class-H insulation can be made with 2/3 the weight of a conventional class-A motor.

EDITOR'S NOTE: These previous articles have helped to pioneer in the rerating and repackaging of motors:

Non-standard Ratings for Integral-hp Motors, June 19 '61, p 59—One manufacturer has added ratings of 2½, 4, 6¼, 8¾ and other hp values in between the standard NEMA designations; the user can choose the motor closest to his need.

NEMA Standards for Those Size-reduced Motors, Feb 3 '58, p 54—Compares the present NEMA frame sizes for 40 to 125 hp with those prior to the big changeover.

What the New NEMA Standards Mean, Dec '53, p 144; **NEMA Rerate Motors,** Nov '55, p 195; and **NEMA Standards for Dc Motors and Generators,** Mid-Oct '56, p H-10—These three articles summarize the NEMA rerate program.

Temperature is the main limitation in motor rating. Here are some recent articles helping to solve the problem.

How to Choose the Right Electrical Insulation, Apr 10 '61, p 41—This is a detailed roundup which compares all of the properties of insulation pertinent to use on motors, and gives detailed descriptions of temperature classes, suitable insulations in each class, and test techniques.

Which Heat Protector for the Motor, Sept 12 '60 p 53—Reviews the problems of motor overload protection and describes the 5 basic inherent-protection schemes. —*F D Yeaple*

Molten salt research points way to

1000-F hydraulic systems

Steady progress in hydraulic component and system design leaves only the fluid as the major block to high-temperature applications.

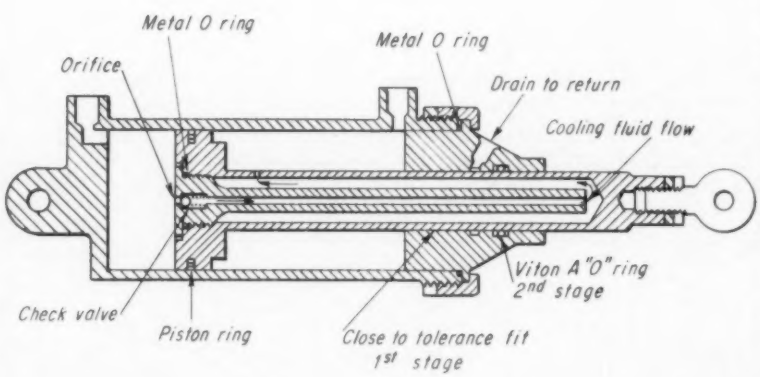
EXTENSIVE research in high-temperature hydraulics, reported at two recent conferences, has produced the requisite new materials, advanced component and system design, and fluids to permit operation in the 750- to 1000-F range and perhaps beyond. Of prime importance, reports William E. Mayhew, Republic Aviation Corp, is simplicity of design. Unnecessary or overly complex components must be left out of any high-temperature hydraulic system design.

The basic rule: A valve not in the system does not malfunction.

The second rule: Judicious component location, can often solve problems with thermal variation. Must a hydraulic cylinder, for example, be located at the point of actuation or can it be mechanically connected to the element it serves? If the service area is hot and there is an adjacent cool area, a linkage will eliminate the problem of high-temperature cylinder design. Weight and performance penalties incurred, of course, must be evaluated against the similar penalties of locating the actuator in the hot area.

Stagnant areas (little or no fluid cir-

COOL AREA LOCATION of actuator permits a lower temperature fluid which, in turn, simplifies construction, cost and weight of the unit. However, added structural complexity, linkage weight, connection slop, and lower spring rate must be evaluated when placing the actuator.



HIGH TEMPERATURE AREA cylinder requires design compromises to keep elements mated and prevent leakage. Here system fluid has a maximum useable temperature of about 500 F. Actuator body is in an ambient temperature area of 800 F. Piston rod, which is extended when pressure is applied, is in an ambient of 1100 F. Piston rings were originally used but, after wear-in, allowed too low a cooling flow. An orifice placed in the piston head produced the required flow, but the 1100-F piston rod scorched the secondary elastomeric seal when piston was actuated. So a coaxial tube carrying the cooling fluid was provided in the piston rod. This effectively increased seal life. Since holding a partially retracted position for a few seconds was a functional requirement, a check valve was installed to prevent two-way flow.

culation) in a high-temperature system are particularly troublesome as trapped fluids can't get back to the heat exchanger. Minimum internal flow or leakage must be provided so that fluids will not decompose in hot areas. This can be done by scoring valve seats and pistons or by opening tolerances at possible trouble points.

In a companion paper, Charles Spar of Republic, described the problems with fluids over 1000 F. Organic materials, such as polyphenyl ethers which work well below 1000 F, tend to break down if held at the upper temperature for any length of time. Experiments with liquid metals and molten salts, show the molten salts to be the best choice.

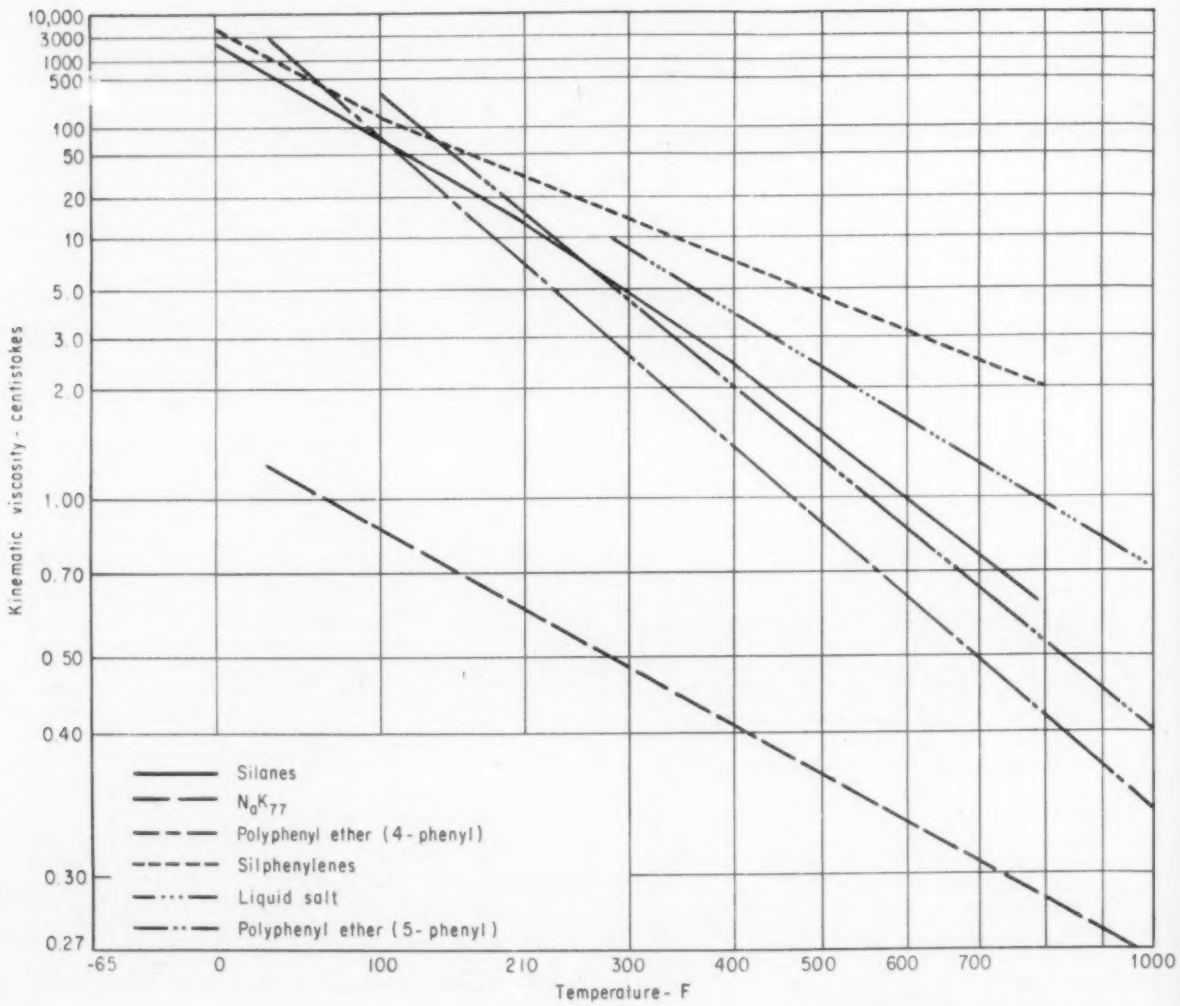
A eutectic mixture of 35% potassium nitrate, 40% sodium nitrite, 7% sodium nitrate, has operated successfully for several hours in the laboratory. The drawback here is that a minimum operating temperature of 350 F is needed. Second problem and a formidable one, is that of finding components that will withstand the high temperature salts for extended periods.

Methods are available, however, such as using a two fluid system with direct contact between the fluids or by inserting a barrier piston which separates the fluids. The second fluid should be stable to at least 400 F and be compatible but not miscible with the molten salt. A mineral oil and a silicone-ester blend have both been used as the second fluid. These materials are immiscible with the molten salt and do not react with the salt in any way. Direct contact is possible as the densities of the fluid are different, but care must be taken to place the second fluid on top of the molten salt to take advantage of the higher density of the salt. The barrier system has the advantage of completely separating the fluids but it adds the complication of another component requiring dynamic seals at elevated temperatures.

Both types of dual fluid systems have been successfully operated. The dual system compensates for the single drawback of the molten salt (high melting point) and permits immediate application.

Another possibility is liquid glass. Some investigations have been conducted with glasses that are liquid to room temperature. However, these

Viscosities and properties of some



glasses have a high vapor pressure resulting in a very narrow liquid range. Nevertheless, the excellent resistance of glasses to thermal degradation and their good lubricating characteristics make them candidates for study.

REFERENCE

Design and Test Considerations for Hydraulic Systems in Severe Environments by William E. Mayhew and Frederic H. Pollard, Republic Aviation Corp. Presented at the Vickers Conference on Aerospace Fluid Power, Detroit, Mich, Oct 30-31, 1961. *Fluid for Extreme Environment* by Charles Spar and Frank Damasco, Republic Aviation Corp. Presented at the Vickers Conference on Aerospace Fluid Power, Detroit, Michigan, Oct 30-31, 1961.

Eutectic melting points

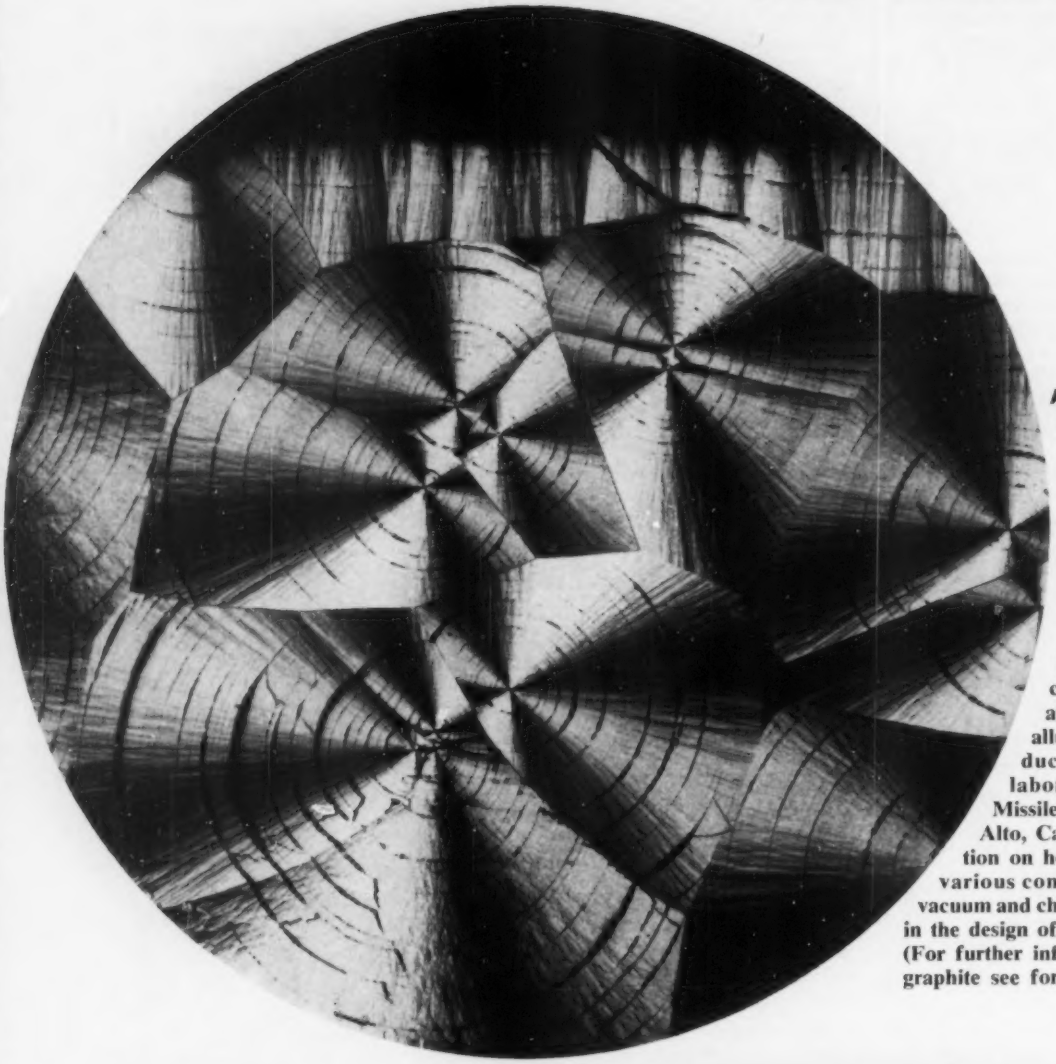
SYSTEM	COMPOSITION	EUTECTIC MELTING POINT (F)
In-Bi	33.7Bi	102
Pb-Cd-Bi	52Bi-8Cd-40Pb	198
In-Sn-Bi	58Bi-17Sn-25In	174
Tl-Pb-Bi	55Bi-33Pb-12Tl	196
Pb-Sn-Cd-Bi	50Bi-10Cd-13Sn-27Pb	158
In-Pb-Sn-Bi	49Bi-12Sn-18Pb-21In	135
In-Cd-Pb-Sn-Bi	45Bi-5Cd-8Sn-23Pb-19In	117

hydraulic-fluids for use above 700 F

	SILICONE ESTER BLENDS	SUPER-REFINED MINERAL-OILS		SILPHENYLENES	SILANES	POLYPHENYL ETHERS		LIQUID METALS	MOLTEN SALTS
	(MLO 59-98)	Naphthenic (MLO-7277)	Paraffinic Deep Dewaxed (MLO 60-294)			4 Phenyl Group	5 Phenyl Group	NaK	$NaNO_2$ • $NaNO_2$ • KNO_3
Max Useful Temp (Approx) (F)	700	700	700	700	700	830/1000*	835/1000	1400/-	1000/2400**
Viscosity (cs) at:									
−65 F	2500	–	27,000	–	–	–	–	–	–
0	800	10,000	360	3500	2500	–	–	–	–
+30	300	1500	110	–	–	2500	–	(1.2)	–
+100	61.8	79	18.2	108	75	70	390	0.81	–
+210	13.5	8.4	4.18	23	12.1	6.3	13.3	0.57	–
+400	3.5	1.7	1.28	7	2.33	1.4	2.2	0.38	3.93
+550	1.9	0.9	(0.81)	3.6	1.16	0.77	1.1	(0.33)	1.47
+700	1.0	0.6	(0.57)	2.4	0.75	0.50	0.7	(0.30)	1.21
+1000	–	–	–	–	–	(0.30)	(0.4)	(0.27)	0.71
Flash Point F	–	445	390	625	555	505	560	Room Temp	–
Fire Point F	–	495	425	690	–	565	680	Room Temp	–
Spontaneous Ignition Temp F	–	–	–	900	750	1100	1100	239	–
Pour Point F	–	−30	−70	–	−15	+19	+40	+10	285 (MP)
Acid No. mg KOH/g	–	0	0	0.01	–	0.04	0.04	–	–
Specific Gravity 20/4 C	–	0.88	0.88	1.01	–	1.18	1.20	0.90	1.81(700 F)
Lubricity	–	Good	Fair	Fair	Good	Good	Good	Very Poor	–
Toxity	–	Low	Low	–	–	Low	Low	Toxic	Low
Radiation Resistance	–	Poor	Poor	–	–	Excellent	Excellent	Excellent	Excellent
Compatibility With Elastomers	Viton	Viton	Viton	Viton	Viton	Viton	Viton	–	–
Boiling Point (F) at:									
10 mm	–	–	–	420	–	552	630	860	–
100 mm	–	–	–	620	–	698	800	1160	–
700 mm	–	–	–	730	–	(900)	(970)	1440	–
Bulk Modulus	–	Good	Good	–	–	Good	Good	Excellent	–

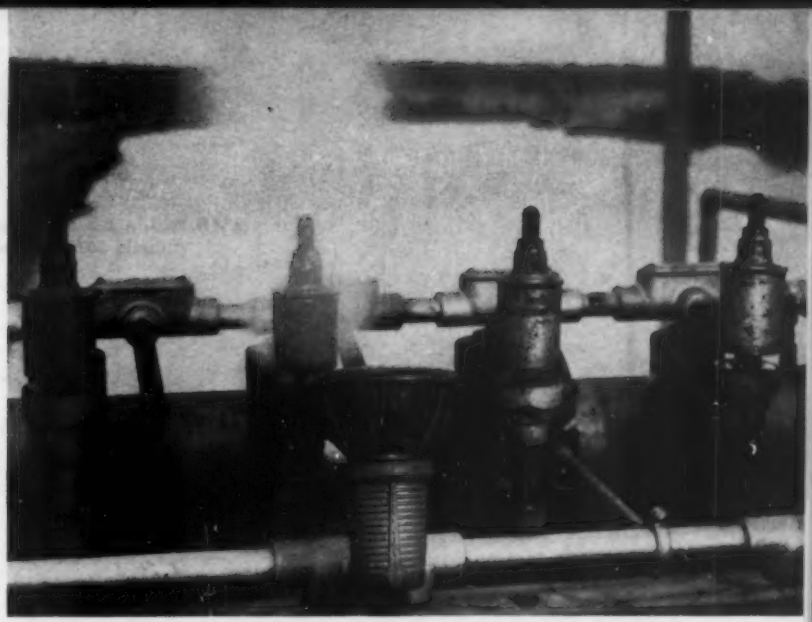
Figures in parentheses are extrapolated *First figures – initial decomposition; second figure – max temp
**First figure applies to salt or metal shown; second figure applies to class of compound

PANORAMA



ABSTRACT ART? No. Pyrolytic graphite magnified 100 times is photographed under polarized light. Photomicrograph shows an abnormal structure of pyrolytic graphite where the vertical growth from a plane surface has been interrupted by excessive growth from relatively few nuclei. Metallurgical studies are conducted at the research laboratories of Lockheed Missiles and Space Co, Palo Alto, Calif, to gather information on how metals react under various conditions of heat, cold, vacuum and chemical treatment to aid in the design of future space vehicles. (For further information on pyrolytic graphite see forthcoming issue.)

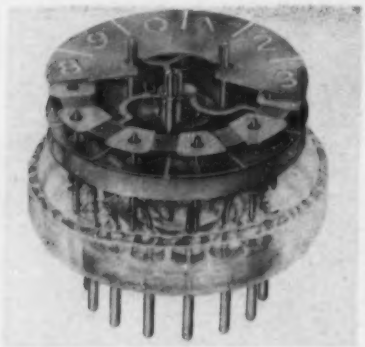
OUT-OF-THIS-WORLD voyage is part of the Spacearium sponsored by the US Science Exhibit Commission and The Boeing Co at the Seattle World's Fair. Project involves the world's largest projection screen, world's largest and widest-angle projection lens, animation, and stop-motion photography. Camera lens projects film over the theater dome—360° horizontally and 160° vertically. The 78-ft dia dome is 38-ft high and covers nearly 8000 sq ft. Projection booth is located in the center of the theater. In filming the solar system, models were constructed of most of the planets, and the sun, each capable of independent movement. In the studio, the camera was moved ¼ in. per frame and the portion of the solar system being filmed was adjusted between each frame according to accurate solar and planetary motion.



MODERN DAY CALLIOPE

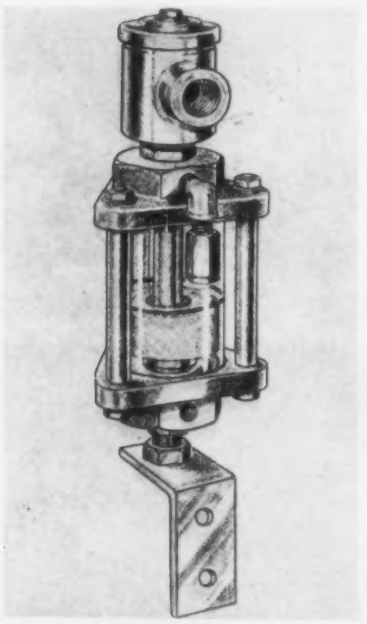
Steam calliopes (organs), the call to circuses, carousels and showboats for 100 years, are almost extinct. Only three (of 60 built in the past century) are still in active service. One, on the sternwheel packet, *Delta Queen*, plying the lower Ohio and the Mississippi, has just been automated. In the old days, the calliopist pressed down heavy keys linked directly to steam valves opening against 25 psi. Because the valves were right at the keys, the brass keys soon became blistering hot as well as hard to operate, and steam and hot water blew everywhere. But the *Delta Queen* now has a very proper 32-key organ-console board, each key with a snap-action switch wired to an electric valve on a timed whistle. The whistles are on the overhead (top deck), while the keyboard is on the sun deck, so colored lights play on the steam; the calliope can be seen as well as heard for 5 miles at night. Shepard Labs of NJ designed the keyboard, working with engineers of Minneapolis-Honeywell's Micro-Switch Division. Thumbtacks under the keys (lower right) press down on 110-volt, 2-amp switches mounted on a wood strip (note 25-psi pressure regulated by pedal). Resistors in series with condensers (center) quench any arcs. Solenoid valves (top) are thus remote-controlled so lights (in the foreground) can make the once-nuisancy steam an aid to the spectacular. The calliope was built in the 1890's, sunk on another packet 25 years ago, resurrected, rebuilt and installed on the *Delta Queen* last year. The *Delta Queen* herself was built in the Twenties to ply the Sacramento River in California.

NEW COMPONENTS



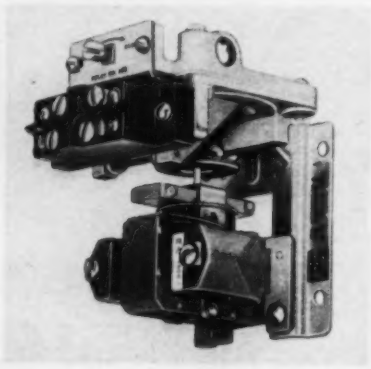
Data tube works off transistors . . . of commonly used, low-voltage type without intervening circuitry. Cold-cathode, gas-filled tube requires less than 5 v at less than 50 microamp to produce discharge, which produces bright red neon glow viewed through appropriate readout aperture. Said to be capable of more than 30,000 hr operation. Samples and production quantities immediately available. **Amperex Electronic Corp, Semiconductor and Special Purpose Tube Div, 230 Duffy Ave, Hicksville, NY.**

Circle 300 on Reader Service Card



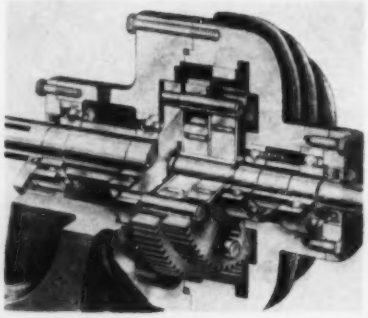
Liquid-level control for bearings . . . opens an electric alarm circuit when oil level falls below predetermined point. Circuit closes automatically when proper level is restored. Designed for outdoor use, will operate with oil temperature of 185 F max, at atmospheric pressure (gravity feed only) light or medium oils. Single-pole switch rated at 1 amp, 120 v ac max, or ½ amp, 120 v dc. **Oil-rite Corp, 2318 Waldo Blvd, Manitowoc, Wis.**

Circle 301 on Reader Service Card



Timing relay uses diaphragm . . . to eliminate need for exhaust valve in pneumatic dashpot. This is said to help maintain accuracy and reliability even in dustiest atmospheres. Diaphragm is made of silicone rubber and is suitable for operation in −45 F to 150 F temperatures. Timing adjustments can be made over 0.2 to 60 sec range. Switching unit suitable for pilot and control circuit applications to 600 v max. **Cutler-Hammer, 315 N 12th, Milwaukee 1.**

Circle 302 on Reader Service Card

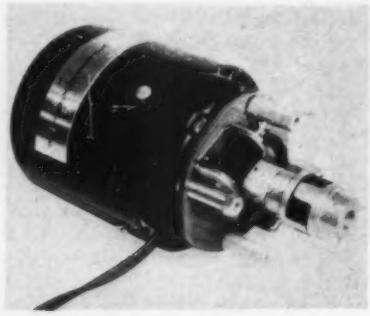


Cycloidal speed reducer . . . provides reduction ratios of 15:1 through 174:1 in a single stage with input and output shafts on same axis. Available in torque ratings of 160 to 6000 lb. Delivery of many standard ratio and torque models is from stock. **Black Tool, Inc, 1824 S Navajo St, Denver 23.**

Circle 303 on Reader Service Card

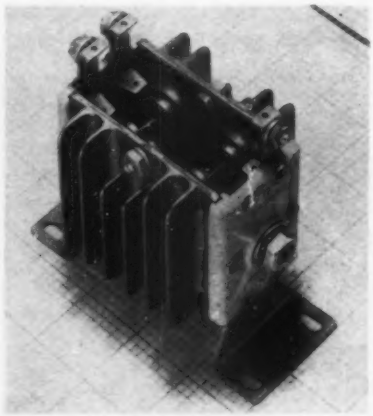
Transducer with double-wall housing is based on a pair of circumferentially wound strain gages arranged so that when pressure medium, admitted to space between walls, expands outside cylinder and compresses inside cylinder, gages form four-active-arm wheatstone bridge. This construction is said to have a compensating effect on the linearity; nonlinearity is 0.15% of full scale, max. Offered in pressure ranges of 500 thought 10,000 psig. **Dynisco, Div American Brake Shoe Co, Cambridge, Mass.**

Circle 304 on Reader Service Card



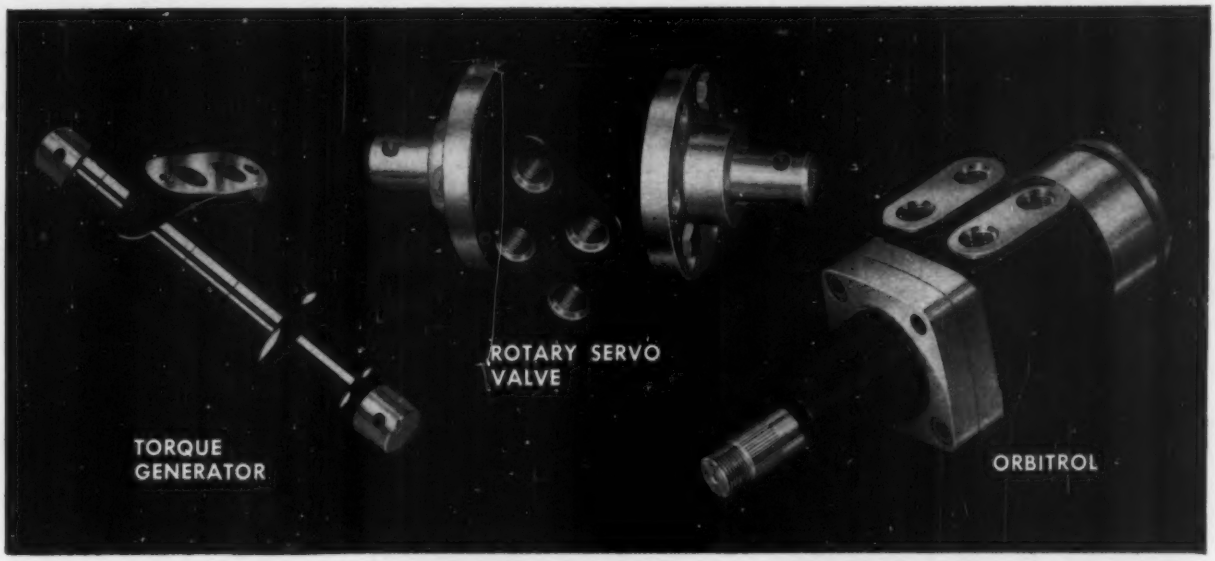
Solenoid-actuated motor clutch . . . is available in start-stop, single revolution, or fractional revolution versions for control and indexing functions. Flexible coupling mounted on output hub allows some misalignment between motor clutch assembly and driven member. Stock model has 1/20 hp, 120 v, 60 cps, 1500 rpm motor. Solenoid is rated 120 v, 60 cps ac. **Precision Specialties, Inc, P O Box 118, Pitman, NJ**

Circle 305 on Reader Service Card



Silcon rectifier bridge . . . consists of press-fit diodes mounted on finned aluminum heat sinks, electrically insulated from one another. Available in either single or three-

continued, page 104



Char-Lynn POWER STEERING

Now available for *all* Types of Vehicles

3 Basic Controls • 30 Standard Models

TORQUE GENERATOR is used to furnish POWERED OPERATION or TORQUE AMPLIFICATION to mechanical steering systems.

This remarkable steering control contains both a Servo Valve and Orbit Motor which delivers up to 1,100 in. lbs. of torque output at 1,000 PSI system pressure. Manual effort at the steering wheel is approximately 30 in. lbs.

Direct thru linkage within the unit provides means for manual steering of the vehicle during "engine off" or emergency conditions.

ROTARY SERVO VALVE is a remote control for steering systems where it is desirable to actuate the linkage by a hydraulic cylinder. Pressure feed-back provides "load feel" at the input shaft proportional to operating pressure. Also contains direct thru linkage for manual steering.

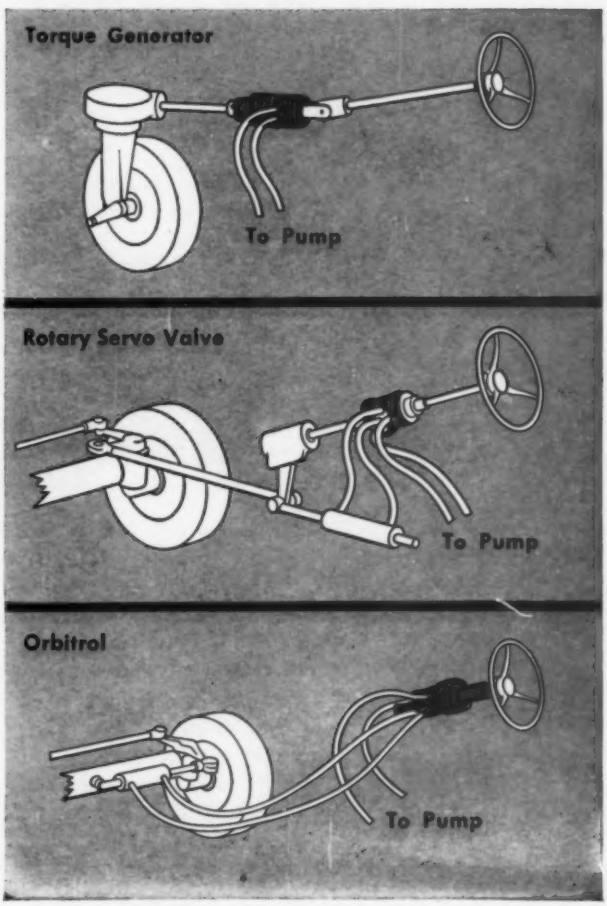
Although designed primarily for power steering systems, this versatile valve has unlimited use in other applications requiring remote servo control.

The all new ORBITROL is a completely integrated fluid steering control that eliminates any mechanical linkage to the axle. The ORBITROL provides remote rotary servo control with sensory direction and delivery measurement within the same unit.

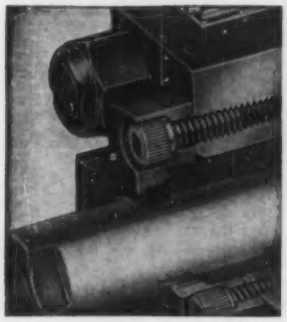
The hydraulic motor section of the Orbitrol functions as a metering device during normal power steering operation and reverts automatically to a rotary hand-pump for emergency manual control.

For complete information write:

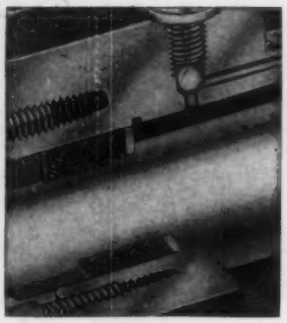
Char-Lynn Co., Dept. P-3
2843 26th Avenue South
Minneapolis 6, Minnesota



Do the cylinders you buy include these quality features?

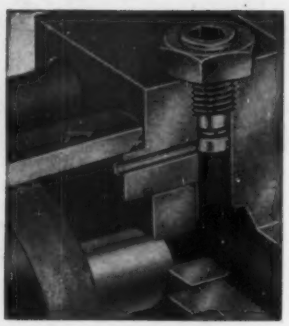


ROD GLAND—Easily removed. No need to loosen tie rods. Cuts maintenance time in half. Phenolic bearing insert will not score rod. Cuts replacement cost to a minimum.

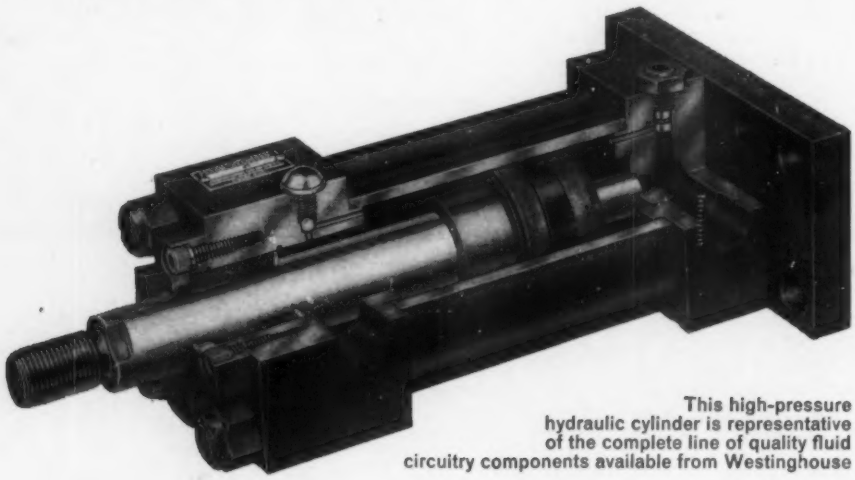


ROD PACKING—Interlocking multiple lip seals require no adjustments; remain flexible under fluid pressure. Wear compensating function eliminates frequent replacement.

PISTON—Phenolic piston will not score tube. Packing cups used for proven long life and seal. Cups are easily replaced. Piston positively locked to rod.



CUSHION—Minimum clearance between piston and Meehanite Bushing combined with micrometer metering give stop cushioning efficiency and a wide adjusting range.



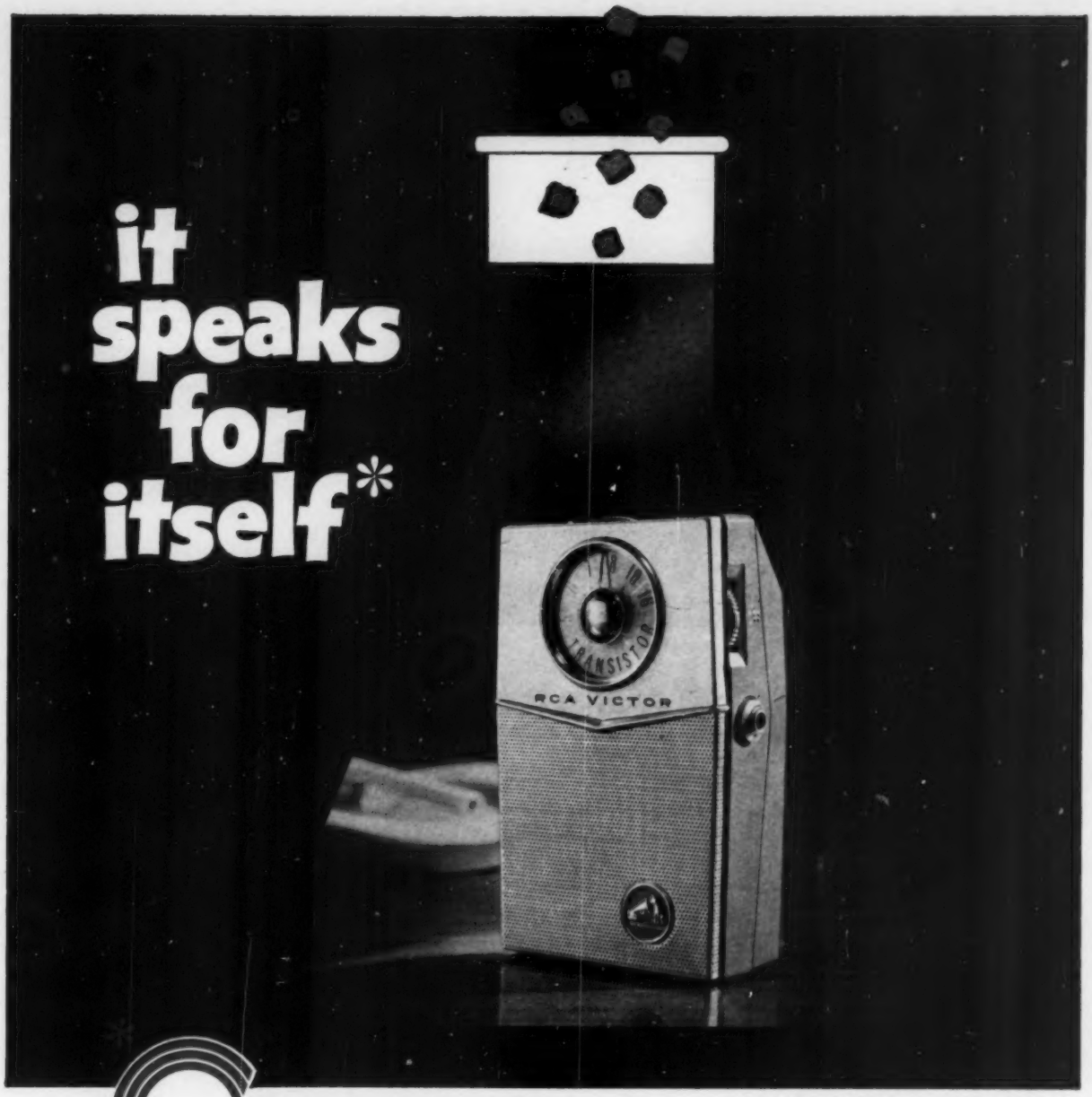
This high-pressure hydraulic cylinder is representative of the complete line of quality fluid circuitry components available from Westinghouse

if not, the chances are, your maintenance costs are higher than necessary. For more information about Quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A3-56.00.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA



MOLDER: Santay Corporation, Chicago, Ill.

CYCOLAC® BRAND

TOUGH, HARD, RIGID POLYMERS FROM BORG-WARNER

Compact, colorful and cordless, this all-transistor radio by RCA Victor is housed in a famous Impac* case that gives rugged service; won't chip, crack or break in normal use. To achieve this dramatic durability, RCA Victor engineers specified cases molded of CYCOLAC brand ABS polymers for their complete line of transistor models. Light and smooth, this most versatile of all rigid plastics defies staining from chemicals and acids and retains its molded-in color for the lifetime of the radio. Easily formed into any intricate shape, CYCOLAC brand plastic lends beauty, protection and saleability to any product . . . radios, television, telephones. See why CYCOLAC is better in more ways than any other plastic. Write Dept. S-12.

MARBON CHEMICAL WASHINGTON — MARBON B-W CHEMICAL — DIVISION **BORG-WARNER** WEST VIRGINIA

*CYCOLAC is the registered trademark of Borg-Warner
*IMPAC is the registered trademark of Radio Corporation of America.

CIRCLE 103 ON READER SERVICE CARD 103

IDEAL FOR AUTOMATED MACHINES

Maxitorq
ELECTRIC
CLUTCHES and BRAKES

Incorporating advanced design principles proved through years of service, the MAXITORQ Electric Clutch is well adapted to all types of machine drives. Simple in design . . . built to machine tool standards . . . requires no adjustments, can be used either as a clutch or brake. Disc separators not only separate discs, but also break up residual magnetism and result in extremely fast, positive action with no drag or heating in neutral. There are few moving parts. Electrical operating unit remains stationary — hence, no troublesome slip rings, brushes, or difficult wiring problems. Operation is on standard 100 V d.c. Other voltages on special order.

If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us. Phone, wire, or write Dept. PE for Bulletin No. 90.

SPECIAL FEATURES

Engaged entirely by magnetic flux.

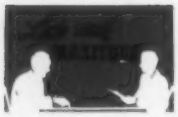
Operate either on-off or by varying voltage for torque control.

NO troublesome slip rings or brushes.

NO levers, cams, or other highly stressed mechanical parts.

Operation is not dependent upon rotation.

Finished complete, assembled, and ready to install on shaft.

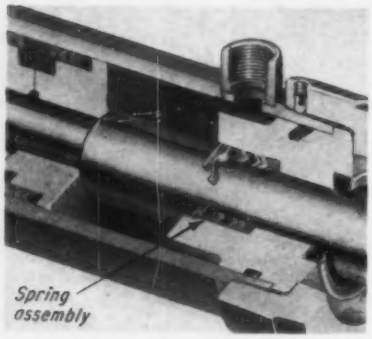


THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER, CONN.

ICJ61

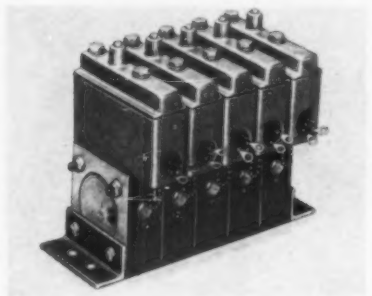
phase, center tap and doubler models. This new design has only 37 parts compared with usual single-phase bridge rectifier assembly's 72 parts. Open box design provides "chimney" cooling effect. Rated at 22 amp, 100 v (rms). **Cyntron Co, Semiconductor Div, Homer City, Penna.**

Circle 306 on Reader Service Card



Hydraulic cylinder has spring . . . assembly that is said to maintain automatically constant preload between packing and rod, preventing leakage resulting from worn packing. Available in standard sizes 2 to 6 in. ID; above 6 and up to 9 in. ID on special order. Suitable for up to 3000 psi. **Ward Hydronics Inc, 11600 Genesee St, Alden, NY.**

Circle 307 on Reader Service Card

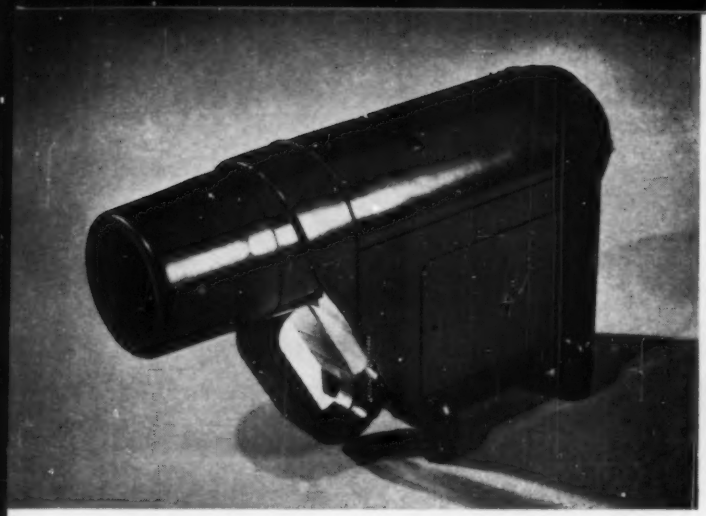


Control valves can be manifolded. . . in banks of up to 16, and mounted in any position. Provides flow rates to 16 cfm at 100 psi, exhausting to atmosphere. For manual, solenoid or remote pilot actuation. Offered in three or four-way types, for air, oil or water service to 125 psi, temperatures to 150 F. **Bellows-Valvair Pneumatics Div, Akron 9.**

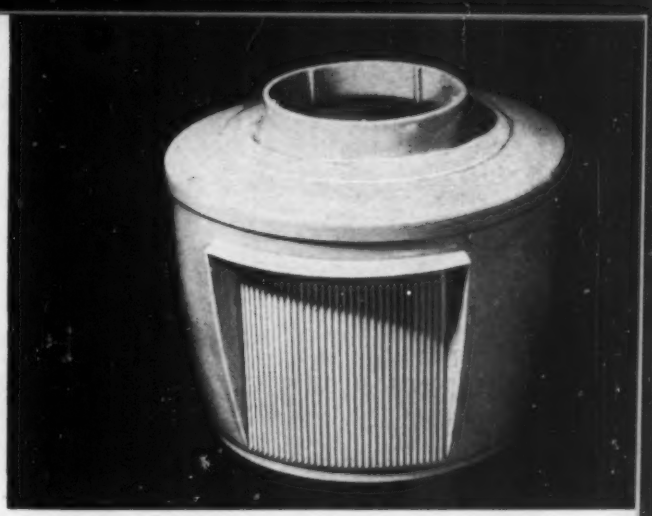
Circle 308 on Reader Service Card

Pressure seal with flexing legs . . . for shafts or cylinders are said to provide own expander, and thus does not require mechanical assist. In service,

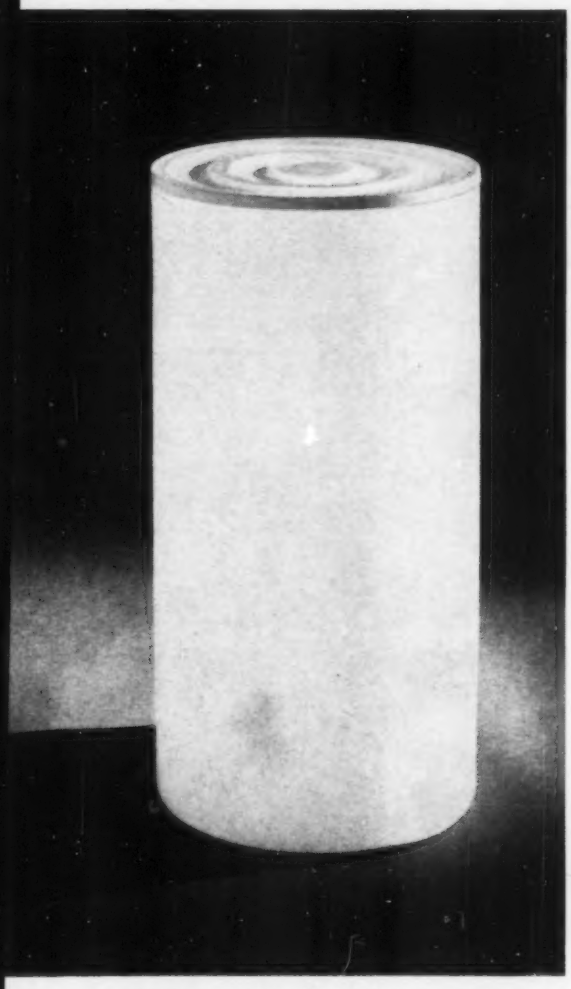
continued, page 111



INSTRUMENT HOUSING—Made of MARLEX, it's lighter and more durable, resists cracking and warping . . . for "Plug-Scope," spark plug tester manufactured for Champion Spark Plug Company by Heyer Industries, Incorporated.



VAPORIZER HOUSING—Attractively styled for a popular Hankscraft product, this component has molded-in color and texture . . . won't warp or crack with boiling temperatures.



BRINE TANK—Welded of MARLEX sheet with Thermoformed top and bottom . . . this Premier Plastics water softener tank will never corrode or scale up . . . gives longer and improved service at low cost.

MARLEX* components for economical "quality up-grading"

To improve product performance while keeping production costs down, more and more manufacturers rely on components molded or formed from MARLEX high density plastics. A representative selection is shown here.

MARLEX plastics (high density polyethylenes and ethylene copolymers) are lightweight, tough, and virtually indestructible . . . resistant to acids, alkalies, greases, fungi, and corrosion. They possess high dielectric strength and a wide usable temperature range (−180°F to 250°F). Components of MARLEX can be molded, thermoformed, extruded, welded, machined, printed upon, and endowed with integral color.

*MARLEX is a trademark for Phillips family of olefin polymers.

RUG WASHER HOUSING—Precisely molded, this rugged Electrolux part of MARLEX is lightweight, tough, and non-corroding . . . will not chip, dent, bend or warp.

For more information, see your plastic fabricator . . . or contact us.

PHILLIPS CHEMICAL COMPANY

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A subsidiary of Phillips Petroleum Company

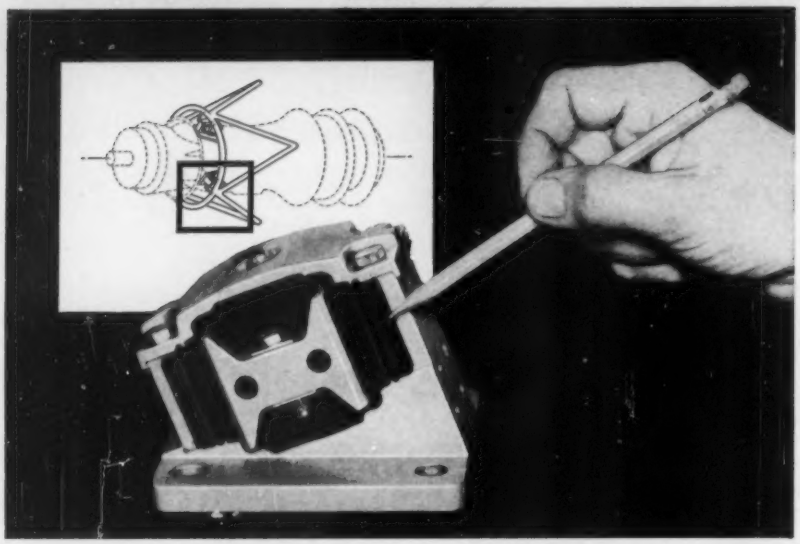
PHILLIPS 66 MARLEX PLASTICS

No. 1 in a series

VIBRATION NOTES

MB ELECTRONICS • DIVISION OF TEXTRON ELECTRONICS, INC.

Representatives in principal cities throughout the world



New MB Synthetic Coating Solves Tough Engine Mount Problem

How do you isolate the vibration of an aircraft engine when none of the available engine mount materials can meet the specifications required? MB engineers had to solve this problem in designing mounts for the turboprop engines of the Grumman Mohawk observation plane. They did it by "manufacturing" a new isolation material... natural rubber covered with a thin film of Iso-Kote, a unique elastomeric coating.

Vibration isolators for the turboprop engine had to withstand high gyroscopic loads; were limited in size by dimensions of engine mounting pad and nacelle structure; and had to be resistant to di-ester lubricant, Turbo Oil #15. Mechanical requirements left no room for compromise. Only natural rubber could meet the rigid specifications of strength, weight, space limitations and low temperature flexibility.

However, natural rubber deteriorates upon exposure for any length of time to the di-ester Turbo Oil. So, unfortunately, do those synthetics generally considered for vibration isolation.

The application of a thin coating of Iso-Kote to natural rubber provided complete resistance against the corrosion and degradation effects of the di-ester lubricant. The coating has excellent adherence and, of particular importance in vibration applications, has the same elongation as natural rubber.

The successful development of this unique engine mount material, combining the mechanical properties of natural rubber and the chemical properties of Iso-Kote, represents another MB achievement in vibration engineering.

MB engineers will be glad to assist you in solving your vibration problems. Send today for our Vibration Mount Catalog. Write to Isomode Division, MB Electronics, P.O. Box 1825, New Haven 8, Conn.

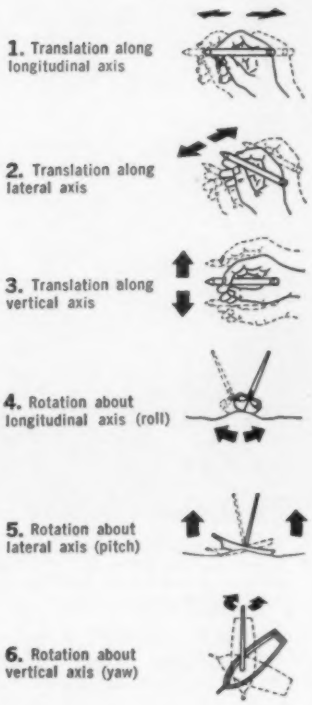
Fundamental Motions of Vibrating Bodies

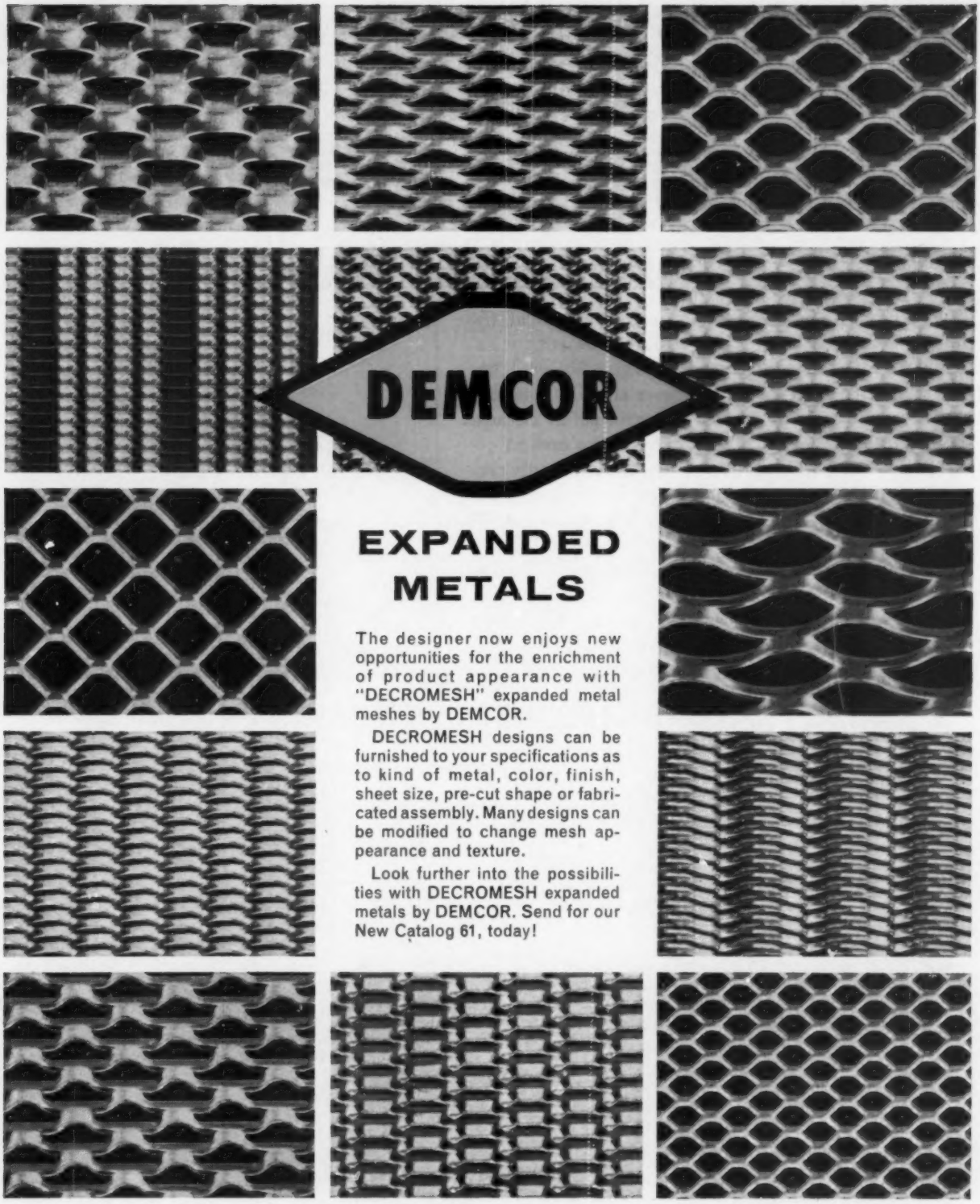
Isomode is the registered trademark of MB's regular line of vibration mounts. The name is derived from the word "isolation" and from the six "modes" of motion to which all rigid bodies are subject.

In actual practice, vibration is seldom confined to a simple, single motion. If it were, control would become a fairly simple matter. But even a rigid body has six degrees of freedom in space as illustrated here.

Complex structures have even more modes of motion. These may involve the relative motion of various rigid bodies or distortion of flexible bodies.

In general, vibration problems lie in the six fundamental motions. Any of these modes may be excited by vibratory forces. To design successful vibration control, you must consider all modes and the excitations to be expected.


1. Translation along longitudinal axis
2. Translation along lateral axis
3. Translation along vertical axis
4. Rotation about longitudinal axis (roll)
5. Rotation about lateral axis (pitch)
6. Rotation about vertical axis (yaw)



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The designer now enjoys new opportunities for the enrichment of product appearance with "DECROMESH" expanded metal meshes by DEMCOR.

DECROMESH designs can be furnished to your specifications as to kind of metal, color, finish, sheet size, pre-cut shape or fabricated assembly. Many designs can be modified to change mesh appearance and texture.

Look further into the possibilities with DECROMESH expanded metals by DEMCOR. Send for our New Catalog 61, today!

DEMCOR

DESIGNERS METAL DIVISION

of Southern Electric, Inc.

8701 SOUTH GREENWOOD AVE., CHICAGO 19, ILLINOIS

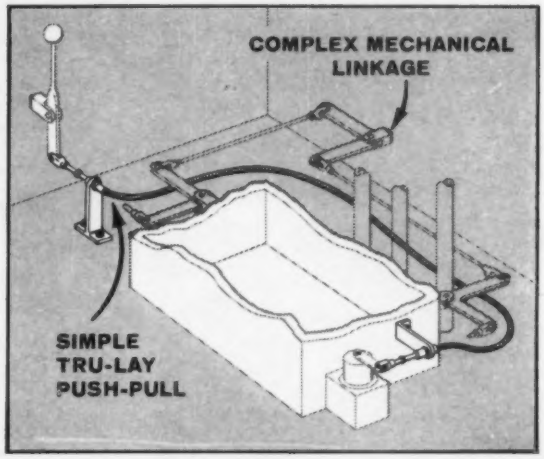
MANUFACTURERS OF MICROMESH, DUROMESH AND DECROMESH EXPANDED METALS

CIRCLE 107 ON READER SERVICE CARD 107

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

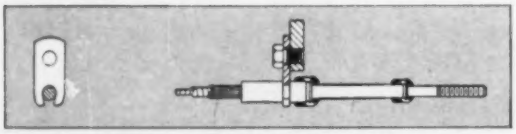
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

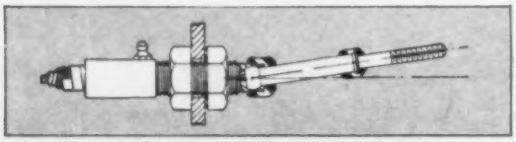


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

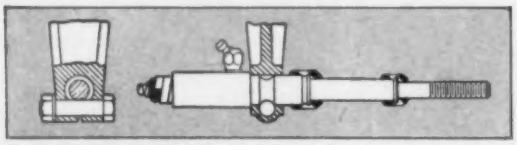
Anchorages



Clip anchorage • a simple clip for light loads

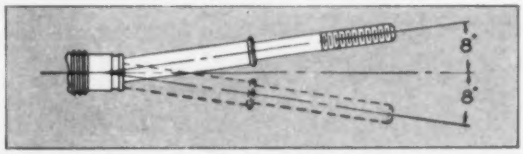


Bulkhead anchorage • for heavy-duty installations



Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN

• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

ACCO

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

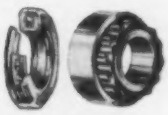
601-E Stephenson Bldg., Detroit 2

6800-E East Acco Street, Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

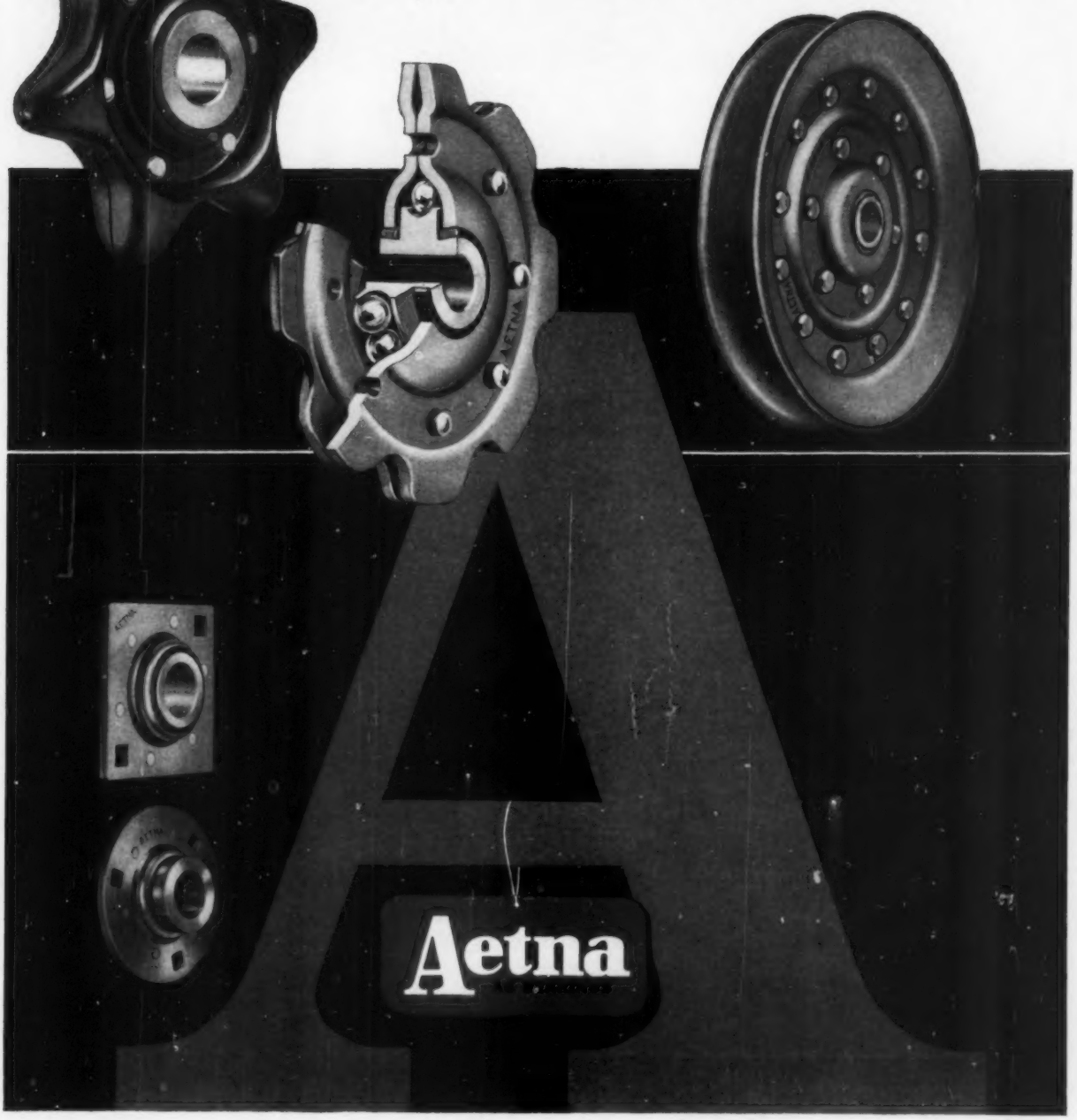
IF YOU USE BELTS OR CHAINS—Long-life, low-cost Aetna AG Series Idlers will increase your drive efficiency. Units are simple in design. Extra large lubricant capacity and highly efficient seals provide dependable anti-friction performance. In operation they never need maintenance. And because they are completely prepackaged and prelubricated, they reduce your production cost, assembly cost, and stock handling problems. Investigate, also, the Aetna AG Series Adapter units for shaft support and other drive and conveying applications. All AG Bearings are available in a wide variety of sizes and configurations. Call your Aetna representative listed in your classified telephone directory for information, or write for General Catalog and Engineering Manual.

AETNA BALL AND ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.



ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916



CIRCLE 109 ON READER SERVICE CARD

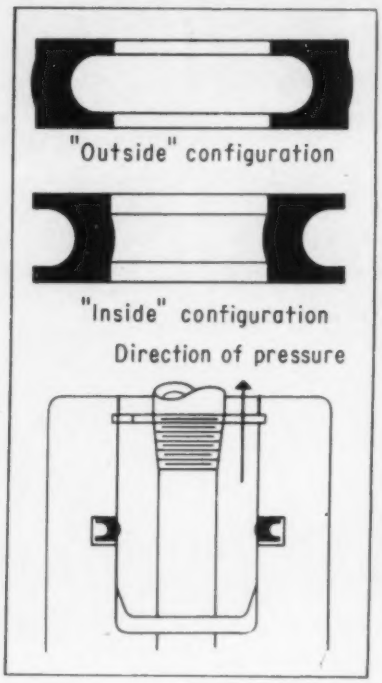
NEW BEETLE* 600 SERIES

Highest gloss of any urea plastic

Now, make your urea moldings come alive with an unmatched surface brilliance—without sacrificing quality or economy. Three new high gloss formulations make this possible: Beetle 650, designed for small parts such as closures and buttons; Beetle 625, for closures, switch plates, wiring devices and small housings; Beetle 600, for large housings and other parts requiring extended flow. These new Beetle molding compounds cure faster, and they offer improved preforming qualities. And you still have all of these dependable Beetle properties: resistance to detergents, oils and grease; arc-resistance; track resistance; good dielectric strength; surface hardness; stain-resistance; wear-resistance; unlimited range of colors. Be among the first to take advantage of this bright new development. Write for complete information today. *BEETLE – registered trademark for Cyanamid's urea-formaldehyde molding compound.

AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION

WALLINGFORD, CONNECTICUT. *OFFICES IN:* BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DETROIT • LOS ANGELES MINNEAPOLIS • NEW YORK • OAKLAND • PHILADELPHIA • ST. LOUIS • SEATTLE • *IN CANADA:* CYANAMID OF CANADA LIMITED, MONTREAL • TORONTO

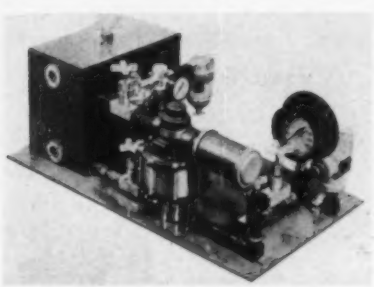


one "leg" of seal is activated by pressure to provide positive sidewall sealing as pressure medium flows around non-engaged leg and back fills seal's hollow arch. This causes expansion against shaft or cylinder wall. Reversing pressure reverses action. Made in both "inside" and "outside" configurations, and will withstand temperatures of −30 F to 500 F. **International Packings Corp, Bristol, NH.**

Circle 309 on Reader Service Card

Repeating cycle timer . . .
is driven by 400-cps synchronous motor said to be accurate to within 2% of over-all cycle time. Cycles of 30 sec to 60 days are possible, based on cam and gear train specified. Weighs 6 oz and measures 2-¼ in. long. **Elgin Micronics, Div Elgin National Watch Co, Elgin, Ill.**

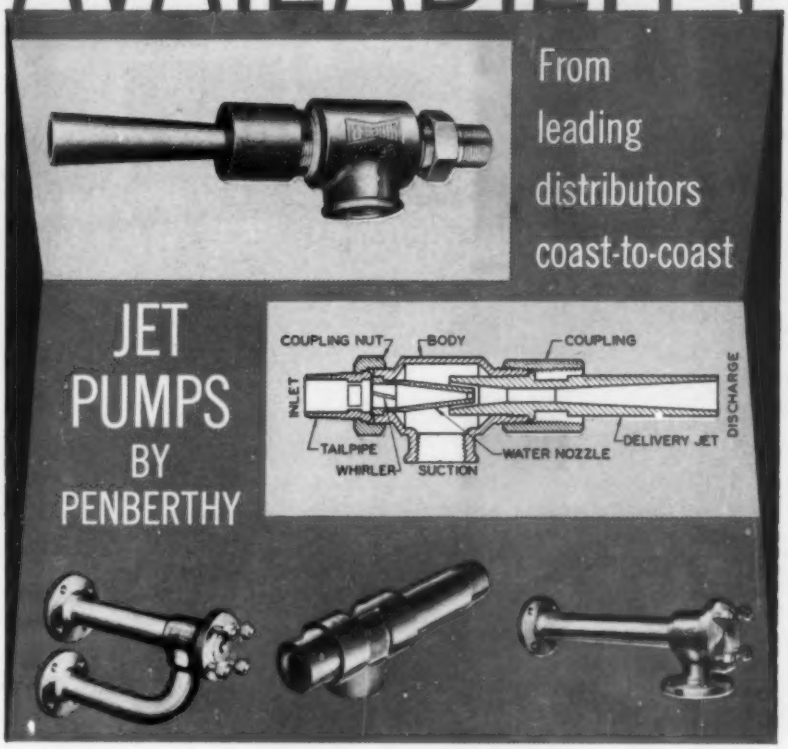
Circle 310 on Reader Service Card



Air-driven hydraulic power unit . . .
designed for use with power presses

continued, page 114

AVAILABILITY



When you want something . . . like a jet pump, for example . . . you *want* it. Not day after tomorrow, or next week, but *now!* Right? And that's just one more advantage of Jet Pumps by Penberthy. Availability . . . *now.*

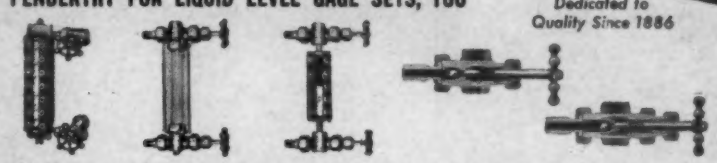
Penberthy, to begin with, has a broader line with more models and sizes to offer . . . hydraulic, air or steam operated . . . in bronze, iron, stainless steel, monel, plastic and other materials. Penberthy, in addition, offers "standards" on many designs that would be labeled "special" by other manufacturers.

Add to the above, Penberthy's nationwide network of representatives and stocking distributors. They're located in all the major metropolitan areas so, chances are, there's a Penberthy man near you. Be happy to supply his name and address . . . write or call the Penberthy sales office at the address below . . .

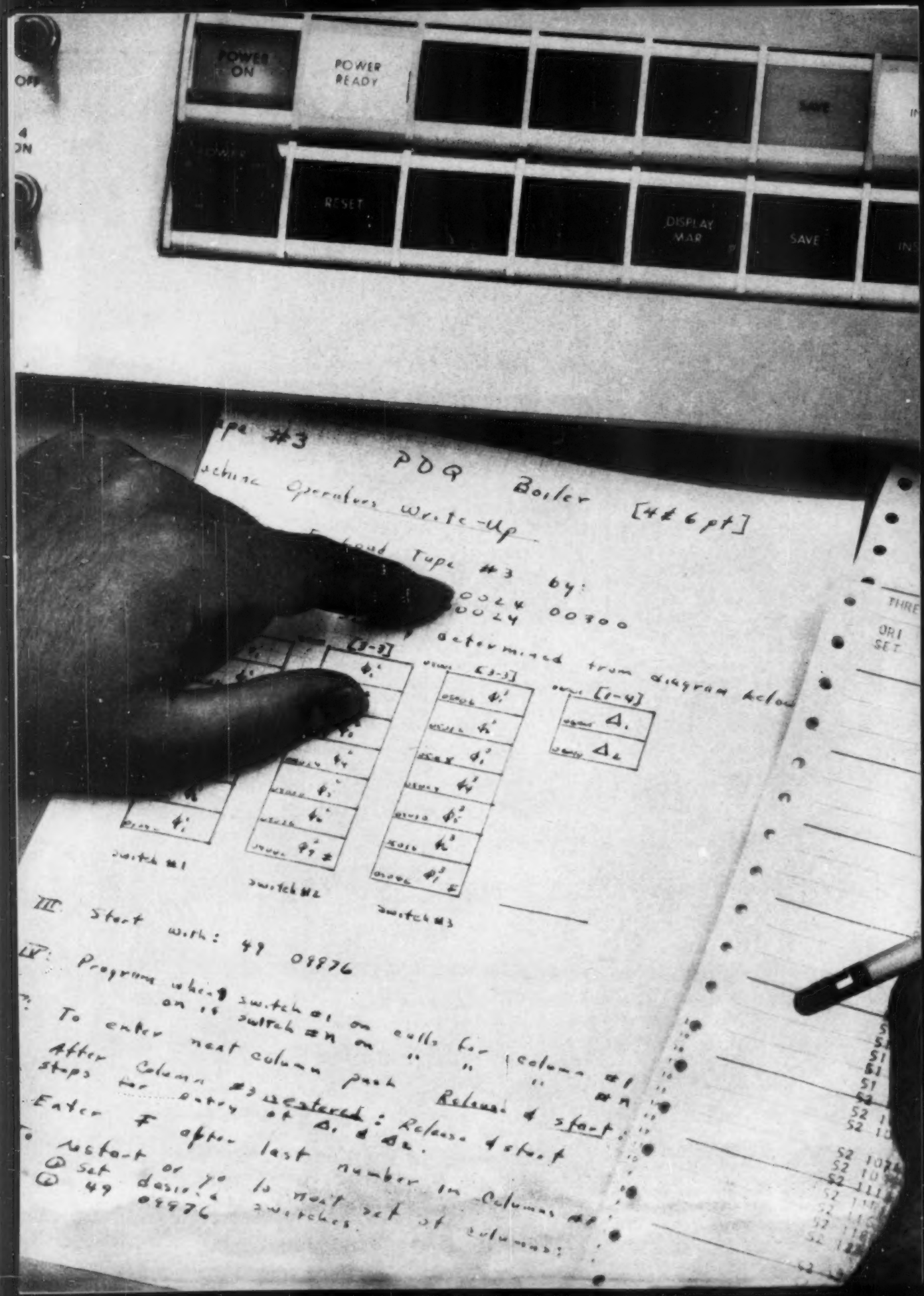
PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

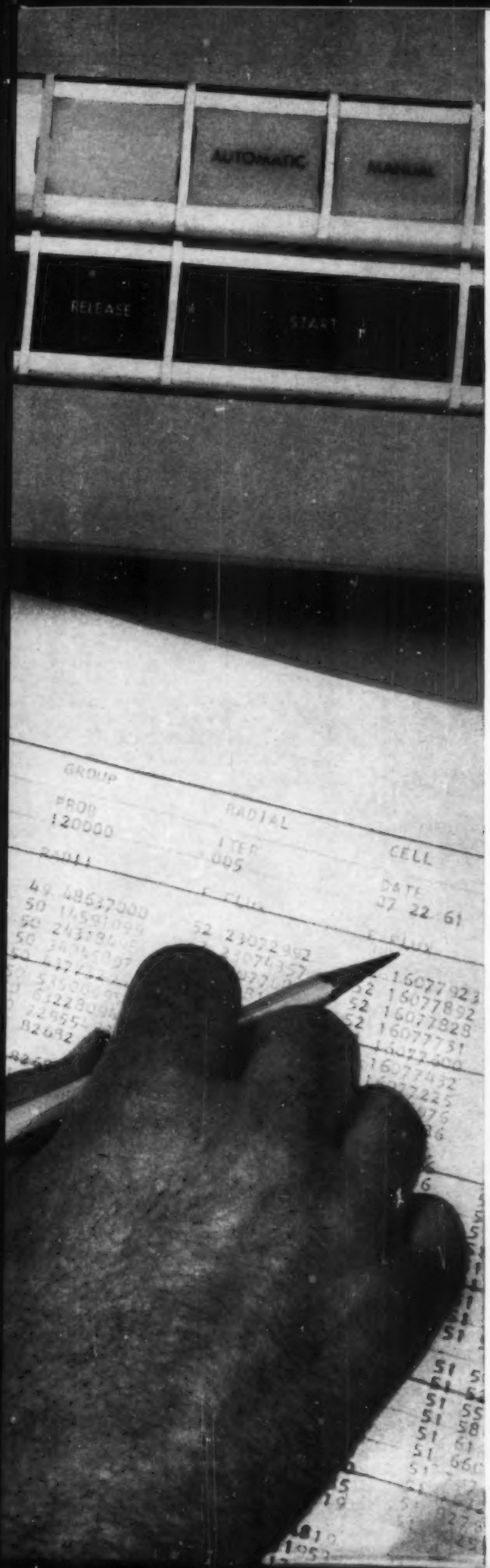
PENBERTHY
Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO



WRITE OR CALL PENBERTHY TODAY FOR COMPLETE INFORMATION


POWER ON
POWER READY
RESET
DISPLAY MAR
SAVE
pe #3
PDQ Boiler [46pt]
chine Operators Write-Up
Load Tape #3 by:
00024 00900
00024
determined from diagram below
switch #1
switch #2
switch #3
III. Start with: 49 09876
IV. Program when switch #1 on calls for column #1
on if switch #N on " " column #N
To enter next column push Release & start
After Column #3 entered: Release & start
steps for entry of Δ1 & Δ2.
Enter F after last number in Columns #3
To select or ? to next set of columns:
① Set desired switches.
② 49 09876



Cost of one-dimensional criticality computations drops from an average of $75.00 to $7.50 per problem

Faster computing, less travel time are the reasons why General Nuclear Engineering Corporation has realized such cost savings since it installed an IBM 1620 Data Processing System at its Dunedin, Florida plant.

Since its main computing facilities are not located at Dunedin, General Nuclear has found that the new 1620 eliminates much of the travel time and expense involved in taking problems to off-site computers. In addition, the 1620 performs the simpler criticality computations 10 times faster than the computer previously used at one of General Nuclear's off-site data processing centers.

General Nuclear uses its new 1620 for other problems, too...heat transfer calculations, various transient codes, mathematical routines for the physics and engineering departments, multi-group calculations, and many other jobs you might expect only a much more expensive computer to be able to handle.

This isn't all. General Nuclear uses the 1620 to do statistical analyses and variance calculations on input data for programs run on off-site large-scale IBM computers.

For information on this highly versatile, low-cost data processing system, which rents for as little as $1600 a month, contact your local IBM Representative.

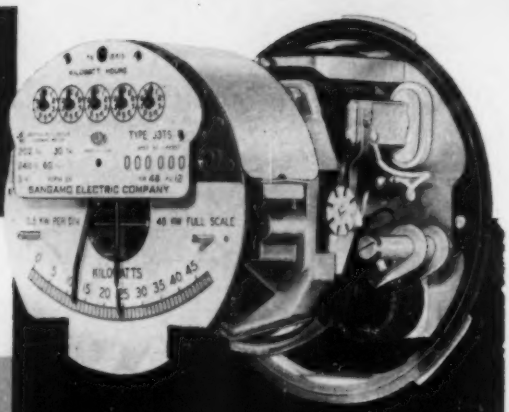
Easy to program. FORTRAN, IBM's scientific computer language is available for the 1620. General Nuclear scientists use a special scientific interpretive program—FIDO—written by the Manager of their Computing Section.

IBM®
DATA PROCESSING

CIRCLE 113 ON READER SERVICE CARD

Chace

A Product Of
Sangamo Electric Company
Springfield, Illinois



THERMOSTATIC BIMETAL
Actuates Another
Precision Product

SANGAMO

The Lincoln
J3TS Demand Meter

Thermal Demand Meters are used extensively by electric utilities. The simplicity and dependability of Sangamo Electric Company's Thermal Demand Meters make them outstanding in the field of demand measurement.

The thermal meter measures load with an inherent time interval and a response curve which is based on the heating effect of the load rather than on counting watthour meter disk revolutions.

Sangamo Thermal Demand Meters are recognized for their excellent accuracy, the result of the simplicity of design. There is only one moving part: the shaft with pusher pointer attached. The shaft is turned as the result of the deflection of two bimetal coils (above) which measure the temperature difference between two electrical heaters (when the two heaters create a heat input difference, the two enclosures develop a temperature difference proportional to the load). The bimetal coils convert the temperature difference into pointer deflection, giving an accurate, average measurement of demand. Ambient temperatures create no inaccuracies, because the two bimetal coils are carefully matched and counterbalance each other as ambient temperature changes. The electrical heaters are also accurately matched; and the enclosures are made of thermal insulating material.

The bimetal coils are precise, carefully selected, matched and stress relieved. The accuracy of many fine Sangamo Meters depends on The W. M. Chace Company's reputation for quality bimetal produced to exacting specifications. Companies large and small, the world over have come to depend on Chace as a result of the utter dependability of its only product: Chace Thermostatic Bimetal.

Send Now For Our New "Information Booklet"!

It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal! More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

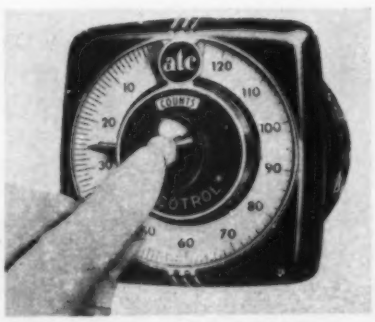
IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1602 BEARD AVE., DETROIT 9, MICH.

and other machinery operates from shop air supplies to provide up to 30,000 psi pressure. Weighs 30 lb and measures 24 x 18 x 16 in. **Kenett Corp, 320 Washington St, Brookline 47, Mass.**

Circle 311 on Reader Service Card

Surface thermostat . . . mounts with single bolt to any flat surface and can be wired in conjunction with alarm devices, pilot lights, solenoids, relays. Available for operating temperatures to 400 F. Contacts are either normally open or closed. **George Ulanet Co, 413 Hudson St, Newark 5. NJ.**

Circle 312 on Reader Service Card



Impulse counter with pushbutton. . . control can be actuated by pulse of as little as 50 millisec duration. With automatic reset, five counting ranges are available: 1-40, 2-120, 4-240, 5-480 and 10-960, at up to 500 counts per minute. Standard load ratings are 10 amp at 115 v ac, 5 amp at 230 v ac, ¼ amp at 115 v dc (non-inductive). **Automatic Timing & Controls, Inc, King of Prussia, Penna.**

Circle 313 on Reader Service Card

Panel-mounting adding counter . . . permits presetting of desired count by means of finger wheels behind hinged

continued, page 118

ARE YOU ACQUAINTED WITH THE NEWEST ADDITION TO UNION CARBIDE'S FAMILY OF PLASTICS

BAKELITE®
POLYPROPYLENE

High heat resistance
●
No stress cracking
●
Lowest specific gravity
●
Outstanding flex life
●
Easy processability
●
Good mechanical, electrical and chemical properties
●
Economical
●
Low MVT and low gas permeability

Investigate BAKELITE® Polypropylene for MOLDING AND EXTRUSION

(All formulations except food grades are heat stabilized for prolonged use at elevated temperatures)

GENERAL PURPOSE: for molding and extrusion.

HIGH IMPACT: 3 to 5 times tougher than general-purpose materials.

FOOD APPLICATIONS: FDA-sanctioned

HIGH FLOW: for deep-draw moldings

U-V STABILIZED: for outdoor applications

BLOW MOLDING: short flow for parison stability

THERMOFORMING: non-sagging

We would be glad to discuss polypropylene or any of our other plastics materials with you. These include high, medium, and low density polyethylene, polyethylene copolymers, phenolics, styrene, epoxy and vinyl resins and compounds. Simply fill out the adjacent coupon.

UNION CARBIDE PLASTICS

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Union Carbide Plastics Company
Division of Union Carbide Corporation
Dept. KQ-113L, 270 Park Avenue, New York 17, N.Y.

I am interested in the possibilities of using polypropylene for_____

NAME_____

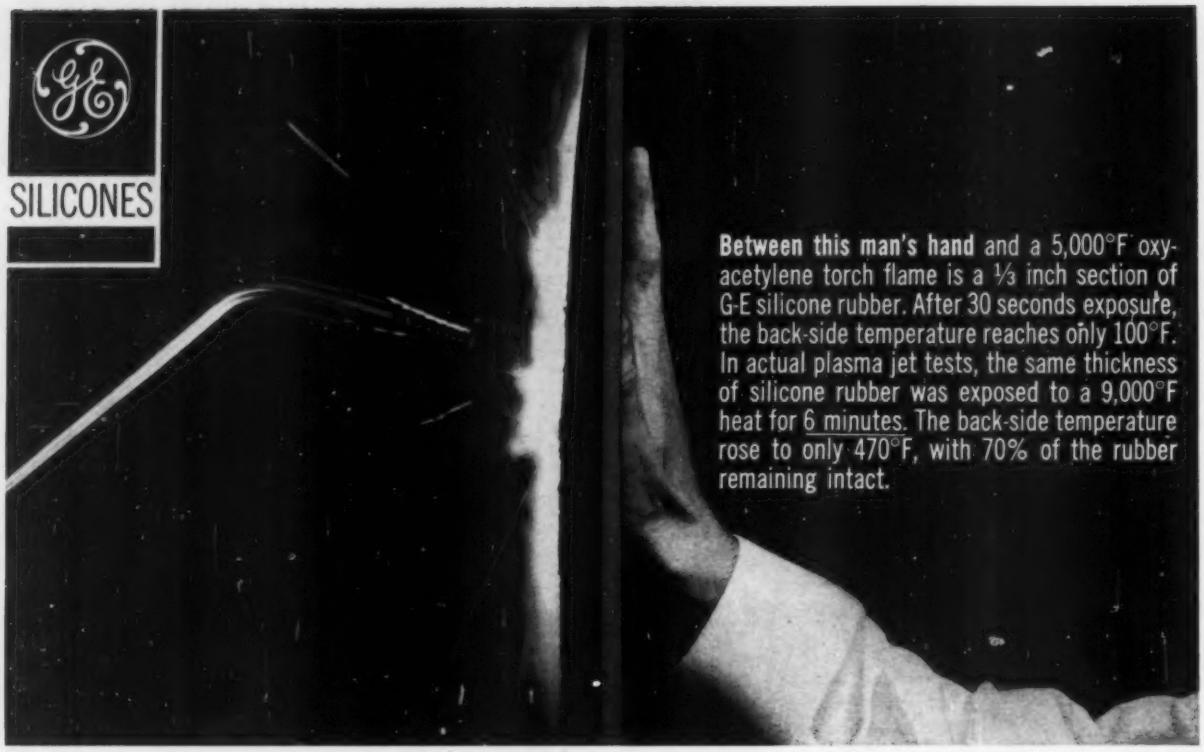
FIRM_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

CIRCLE 115 ON READER SERVICE CARD 115

SILICONES



Between this man's hand and a 5,000°F oxy-acetylene torch flame is a ⅓ inch section of G-E silicone rubber. After 30 seconds exposure, the back-side temperature reaches only 100°F. In actual plasma jet tests, the same thickness of silicone rubber was exposed to a 9,000°F heat for 6 minutes. The back-side temperature rose to only 470°F, with 70% of the rubber remaining intact.

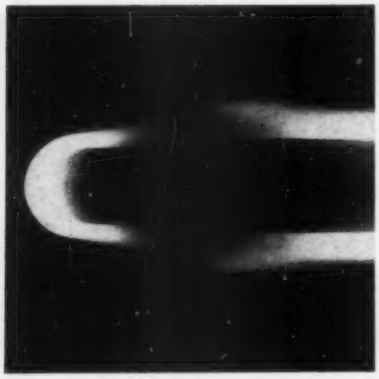
Thermal barrier against 5000°F flame

GENERAL ELECTRIC SILICONE RUBBER

RESULTS OF PLASMA JET TESTS AT 9,000°F

Flight Simulation
Vel. = 17,000 ft./sec.
Alt. = 250,000 ft.

Exposure time at 9,000°F	Back-side temperature of ⅓ inch section of G-E silicone rubber
30 seconds	100°F
2 minutes	210°F
3 minutes	300°F
4 minutes	375°F
5 minutes	430°F
6 minutes	470°F



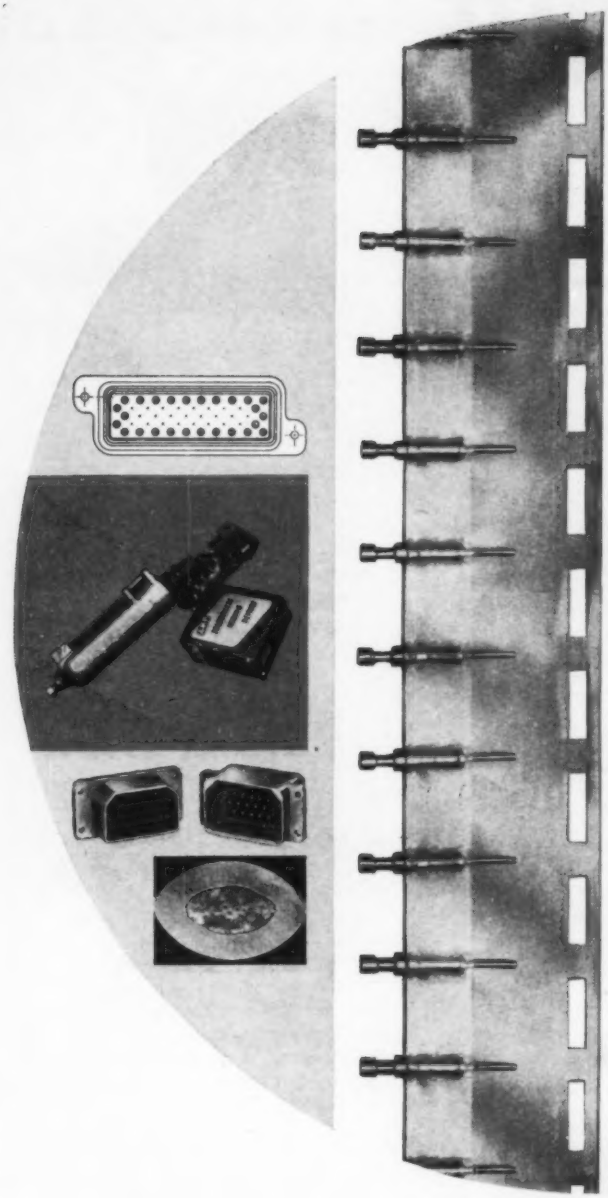
The surface of the tested rubber section forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

The above chart shows how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.

Continued high temperature testing goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section A1261, Waterford, New York.

GENERAL ELECTRIC



TIME CAN BE MONEY SLIPPING AWAY

When time counts, it usually adds up to money! Profit-nibbling time lost.

In the case of pin and socket connections, add the uncertain reliability of other methods of terminating connections and you've got good reason to consider AMPin-cert* Connectors with crimped, snap-in contacts.

AMPin-cert tape-fed, pin and socket contacts are precision crimped to leads on the AMP* Automachine at rates of more than 1,600 per hour. High production rates, maximum reliability and low cost of semi-skilled labor combine with dependable connector performance for the lowest installed cost in the industry.

Make a simple, preliminary test. Check these AMPin-cert Connector features against whatever you're presently using:

- Compression crimping of leads to contact for maximum reliability backed by more than 20 years of AMP experience in solderless termination techniques
- Choice of five types of contacts
- Snap-in design contacts with cantilever beam construction for easy insertion and dependable retention forces
- Choice of phenolic or diallylphthalate housings with or without cadmium plated aluminum shells in standard or environmentally sealed designs
- Wide variety of configurations and sizes and complete line of matching hardware and accessories.

Complete information will be sent upon request. Write today!

*Trademark of AMP Inc.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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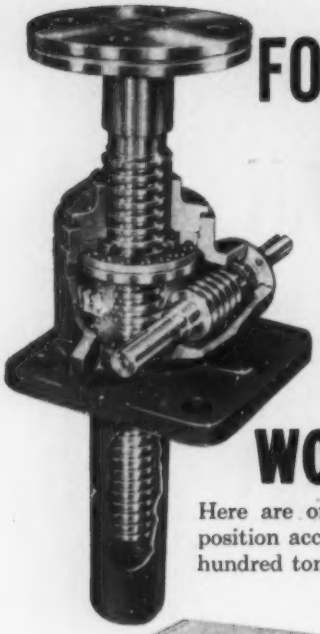
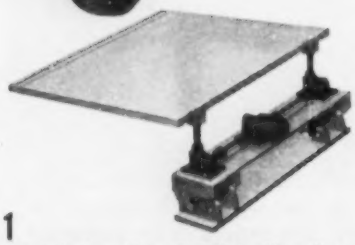


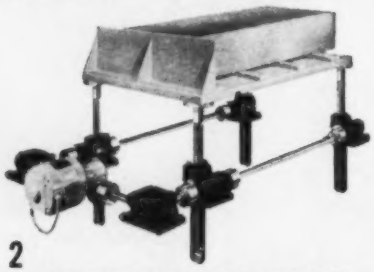
FOR ACCURATE MOVEMENT OF LOADS...USE DUFF-NORTON WORM GEAR JACKS

Here are only four examples of the many ways to position accurately loads weighing as much as several hundred tons with Duff-Norton Worm Gear Jacks.



1

An application with two Duff-Norton Worm Gear Jacks mounted on swivel subbase and each lifting screw end fastened to hinged member by means of clevis and pin. Jacks may be motor driven or manually operated.

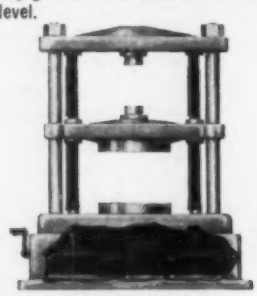


2

Four Duff-Norton Worm Gear Jacks connected in rectangular arrangement by Duff-Norton Mitre Gear Boxes, shafting and flexible couplings and driven by gear motor to raise metal sheets to press level.

3

Six Duff-Norton Worm Gear Jacks as used on pipe-cut-off and threading machines to adjust height of machine spindle to level of conveyor table to compensate for various sizes of pipe.



4

Platen pressure obtained positively and uniformly by two Duff-Norton Worm Gear Jacks with rotating screws.

There are eight standard models of these jacks—capacities range from 2 to 100 tons, with standard raises up to 24 inches.

For engineering drawings of standard jacks, mitre gear boxes and more examples of how Duff-Norton Worm Gear Jacks are used for accurate movement of loads, write for Bulletin AD-66a-DD.

DUFF-NORTON JACKS

DUFF-NORTON COMPANY

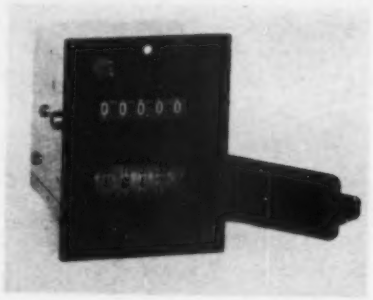
Four Gateway Center, Pittsburgh 22, Pennsylvania

The Canadian Duff-Norton Co., Ltd., Toronto 6, Ontario

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

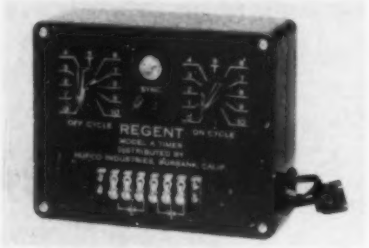
DUFF-NORTON

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric



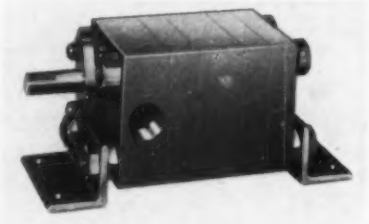
cover, and provides digital readout of progress count on separate, exposed window. Upon reaching preset count, SPDT switch is automatically thrown, and can be reset to normal only by pushbutton. Count rate is 25 per sec, panel dimensions, 2-½ x 3-⅜ in. List price, $56.50; delivery from stock. **Presin Co, Inc, 2014 Broadway, Santa Monica, Calif.**

Circle 314 on Reader Service Card



Electronic recycling timer . . . provides independently adjustable on and off cycles of 0.05 to 5 sec. Unit is double-pole, double-throw 10 amp, 115 v ac relay, equipped with synchronous switch. Power consumption at peak is less than 3 w. Measures 6-$\frac{13}{16}$ x 5-$\frac{9}{32}$ x 2-$\frac{5}{32}$ in.; weight, less than 2 lb. Price, $49.50, delivery, 1-2 wk. **Hufco Industries, Inc, 2815 W Olive Ave, Burbank, Calif.**

Circle 315 on Reader Service Card

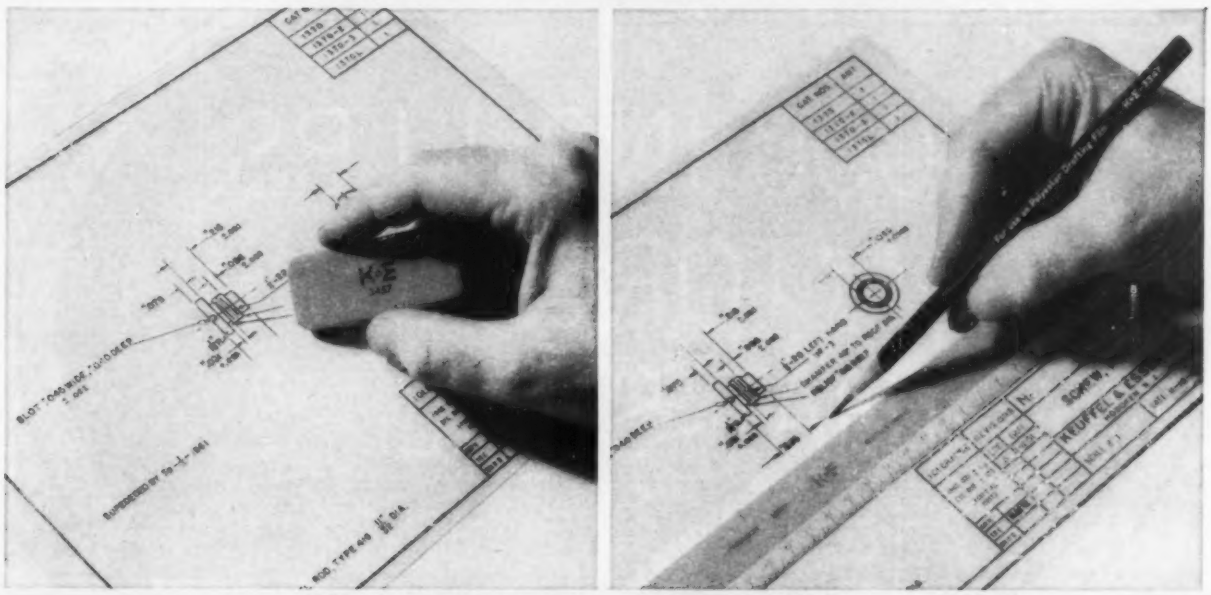


Rotary gear pump . . . is based on self-aligning, floating gear with a "building-block" type of housing, which is said to make it possible to meet individual performance specs at minimum cost. Available in viscosity ratings of 300,000 to 30 ssu;

continued, page 124

For engineering "duplicate originals"...

Use the Polyester Films you can work on



PHOTACT® by K&E

To perfect an engineering drawing requires constant revision, addition and change. Yet most photographic polyester films on the market today reflect a disregard for this fact by combining photo emulsion and drafting surface in a single surface layer. If you mechanically erase image lines on these films the drafting surface is removed, and pencil or ink will no longer take on the film surface. The only alternative is to use eradicators, a time-wasting, nerve-frazzling process.

Only PHOTACT Polyester Films have an additional drafting surface *beneath* the photo emulsion. No eradicators needed. Repeated erasures easily made. In short, the answer to a draftsman's prayers.

Erase cleanly. Using a mildly abrasive Van Dyke eraser (K&E 3457) image lines can be whisked off completely in nothing flat. Even tight, detail lines which are too tightly arranged for eradicators can be removed with a stick-pencil eraser.

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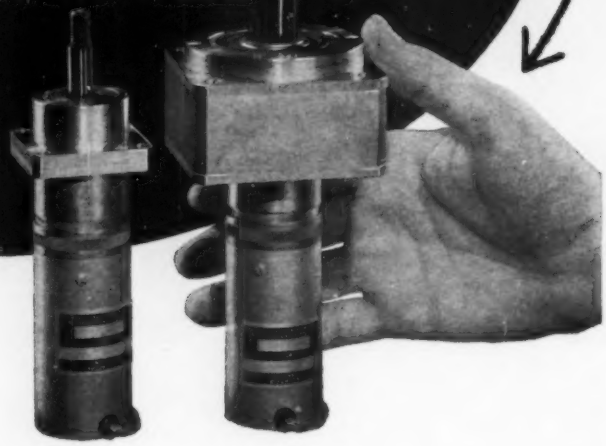

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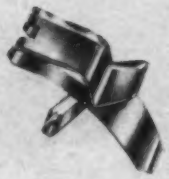

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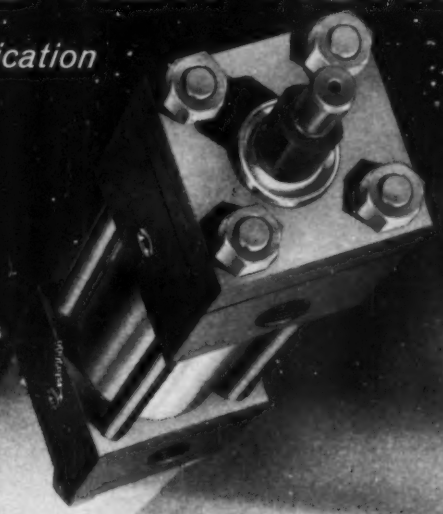

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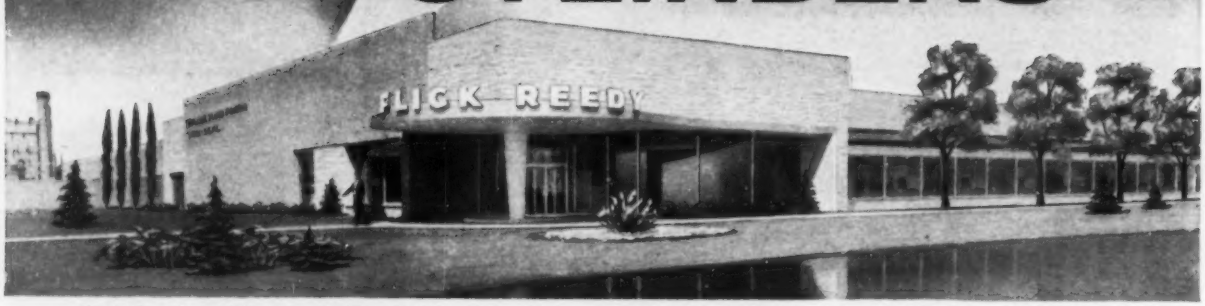

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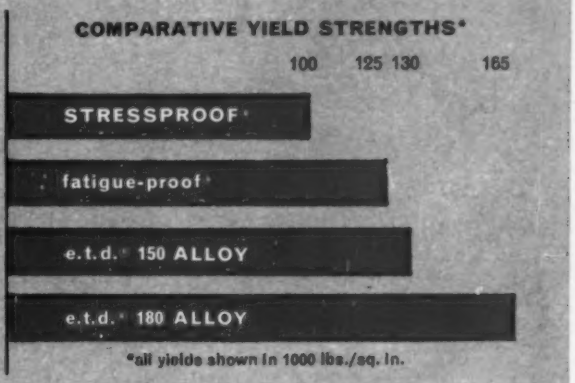

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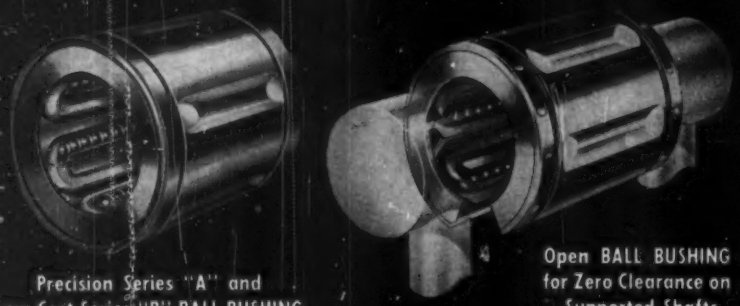

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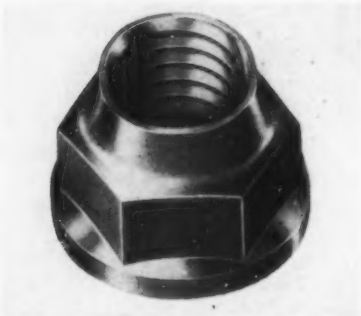

Reusable hex locknut . . . is held in place by elliptically shaped top threads, which apply locking pressure on matching—but circular—threads of bolt or screw. Made with Class B threads, available sizes range from No. 10 through ½ in., UNG or UNF threads. **Allen Mfg Co, Lokon Locnut Div, Hartford 1.**

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Multiple switching assemblies . . . of 6 to 12 units consist of three-position lever-type switches or two-posi-

continued, page 132

←CIRCLE 124 ON READER SERVICE CARD

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250 P. S. I. four-way air valves in ¼, ⅜ and ½ inch pipe sizes.

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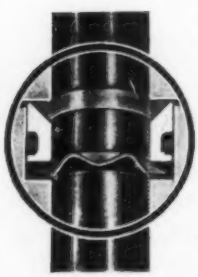


None of the operating advantages of this rugged *'Shear-Seal'* valve has been reduced one iota!

. . . same non-corrosive construction throughout — eliminates failures due to rust.

. . . same long wearing leak-proof qualities — metal to metal *'Shear-Seal'* design is not sensitive to dirt, compensates for wear.

. . . same installation savings — because no oilers or filters are needed.

Only the exterior has been modified — tailored to the special preference of the Original Equipment Manufacturers — and, as a result, costs and prices have been substantially reduced.

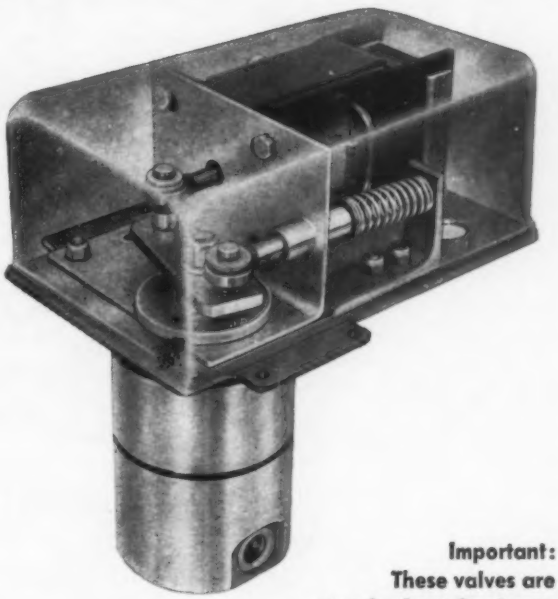
Write for bulletin 5000 which includes design specs.

CONTROL VALVE DIVISION

barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).
Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.

CONTROL VALVE DIVISION

barksdale valves

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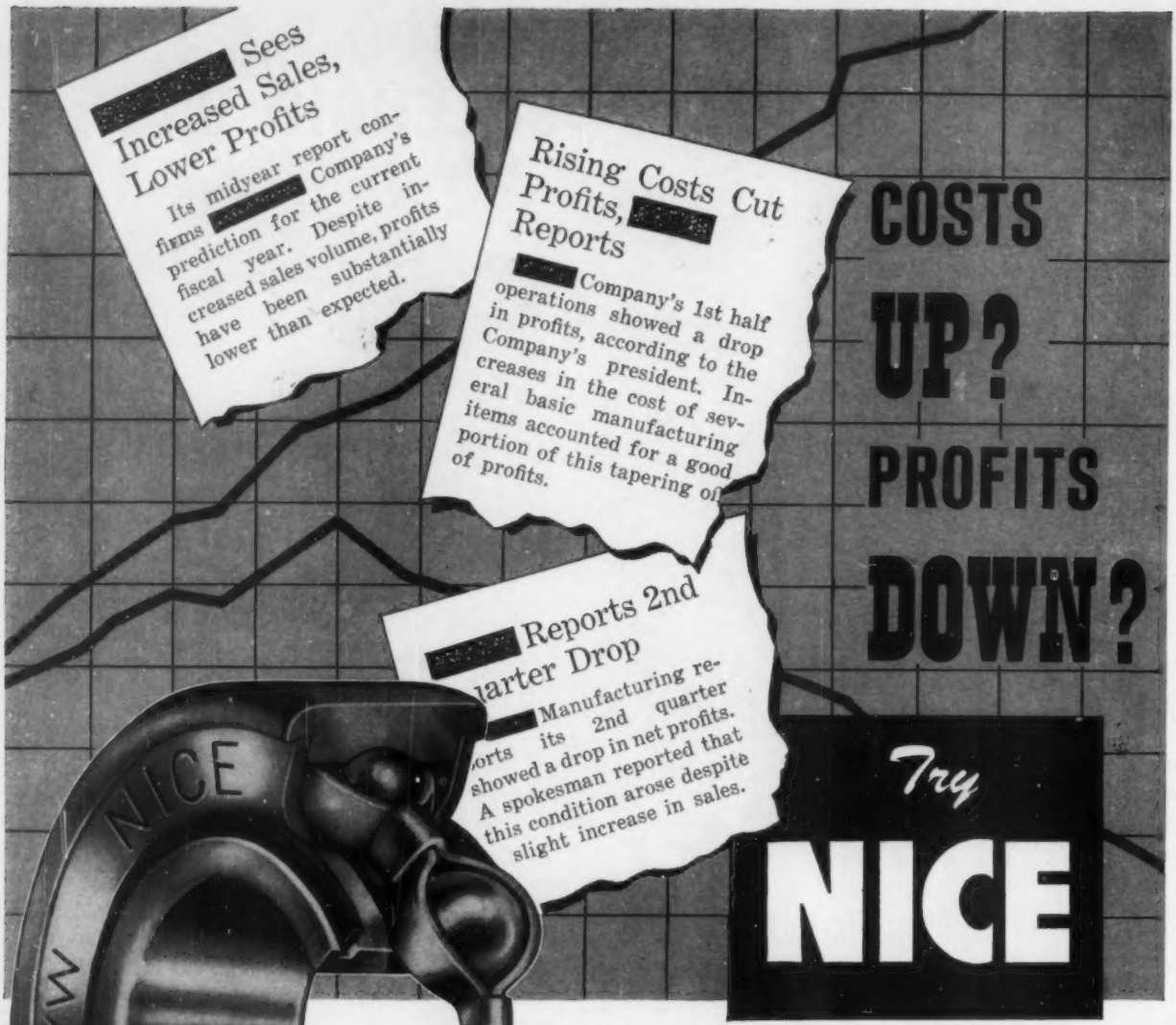
[redacted] Sees Increased Sales, Lower Profits
Its midyear report confirms [redacted] Company's prediction for the current fiscal year. Despite increased sales volume, profits have been substantially lower than expected.
Rising Costs Cut Profits, [redacted] Reports
[redacted] Company's 1st half operations showed a drop in profits, according to the Company's president. Increases in the cost of several basic manufacturing items accounted for a good portion of this tapering of profits.
[redacted] Reports 2nd Quarter Drop
[redacted] Manufacturing reports its 2nd quarter showed a drop in net profits. A spokesman reported that this condition arose despite slight increase in sales.
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Your turn

...to participate in the current problems of our profession.

There are many ways to solve a set of simultaneous algebraic equations. The most straightforward ones, those that depend on subtraction or substitution, are unmanageable when there are a large number of unknowns or when the coefficients of the unknowns are not integers. Here is a method which, while not as straightforward, is convenient to use as well as powerful. It is called the relaxation method and is explained by Richard C. Bollinger of the Mathematics Dept at Westinghouse Research Laboratories.

The relaxation method is a technique for solving a set of algebraic, linear, simultaneous equations by a process of successive approximations. The method was first developed for determining stresses in loaded frameworks, a heritage that has colored its vocabulary with such terms as "relax", "constraint" and "displacement", even when the method is applied to nonframework problems. In brief, the physical interpretation of the method is that of a loaded framework supported by inelastic constraints such that the constraints bear all the load; the stress analyst relaxes the imaginary constraints one at a time, making note of the effect of each relaxation, until the framework bears all the load and the constraints bear none. In this way, he converges on the approximate load carried by each member.

But this mechanical interpretation is not necessary to an understanding of the mathematical method. To solve a set of simultaneous equations, first rewrite the equations, including a factor representing the error (called a residual) in any approximate solution.

$$\begin{aligned} 10x_1 - 2x_2 + x_3 - 185 &= r_1 \\ -3x_1 - 6x_2 + 2x_3 - 93 &= r_2 \\ x_1 - 2x_2 - 5x_3 - 49 &= r_3 \end{aligned}$$

The solution can now be found by reducing the residuals to zero.

Begin with a table that shows the change in the residual with a one-unit change in each variable.

	Δr_1	Δr_2	Δr_3
$\Delta x_1 = 1$	10	−3	1
$\Delta x_2 = 1$	−2	−6	−2
$\Delta x_3 = 1$	1	2	−5

This table serves as a guide for the successive approximations. As a first guess, it is usually best to assume that all the x's are zero (corresponding to a framework in which all the load is supported by the constraints). In that case the residuals are $r_1 = -185$, $r_2 = -93$, $r_3 = -49$. Now directing our attention to the largest residual, r_1, we find that we can "relax this constraint," (or nearly so) by assuming $x_1 = 18$. Now the residuals are $r_1 = -5$, $r_2 = -147$, $r_3 = -31$. Continuing with the approximations, we now attack r_2 by assuming $x_2 = -24$. Notice that we use a different x to relay each r. The results of each relaxation are shown below.

Step	x_1	x_2	x_3	r_1	r_2	r_3
0	0	0	0	−185	−93	−49
1	18	.....	.....	−5	−147	−31
2	.....	−24	.....	+43	−3	+17
3	−4	.....	.....	+3	+9	+13
4	.....	.....	2	+5	+13	+3
5	.....	2	.....	+1	+1	−1
6	.....	.....	−0.2	+0.8	+0.6	0
7	.....	0.1	.....	+0.6	0	−0.2
8	−0.05	.....	.....	+0.1	0.15	−0.25
9	.....	.....	−0.05	+0.05	+0.05	0
	13.95	−21.9	1.75	+0.05	+0.05	0

Recorded this way, the values of all residuals are shown at each step while only the

change in x is shown. When the r's get reasonably close to zero, the answer is found by summing each x column. The exact answer is $x_1 = 13.95$, $x_2 = 21.89$, $x_3 = 1.75$.

The advantage of the relaxation method over less flexible iterative techniques is that it allows you to exercise your insight into the problem and to try tricks that may cause faster convergence. For example, experienced relaxers sometimes relax several constraints simultaneously, or purposely over-relax or under-relax a constraint. As you gain experience with the method, you will be able to apply more of these tricks.

Here are some suggestions that will help you get faster answers to sets of simultaneous equations with the relaxation technique.

- The example above was particularly simple because the coefficients were all integers. When problems have coefficients of several significant figures, the usual practice is to round off the coefficient to one or two digits and solve in the usual way. When the residuals approach zero, you can switch back to the exact coefficients for a precise answer.
- It is not always best practice to relax the largest residual. Faster convergence is often possible by relaxing the residual with the largest $\Delta r/\Delta x$.
- Not all problems converge on a solution. And some that do converge, do it very slowly. Experienced relaxers suggest that if removal of small residuals requires large changes in the unknowns, it may be quicker to try a direct method.
- The method is not suitable for sets of equations having the same matrix of coefficients, but different right-hand sides. For these, it is best to invert the matrix and use another method.
- There is little point in reducing a residual to zero exactly; it will undoubtedly change again when you make your next approximation.
- Because the constraints are relaxed at random, the method lends itself much better to manual solution (with the opportunity for computational short-cuts) than to automatic computation.

Now you try:

Here is a set of simultaneous equations that can be solved by the relaxation method. The answer is on p 130.

$$\begin{aligned} 2x_1 + 0.48x_2 + 3x_3 - 9x_4 &= 28 \\ 5x_1 + 4x_2 - x_3 + 3x_4 &= 85 \\ 0.833x_1 + 3x_2 + 12x_3 - 6x_4 &= 127 \\ 2.5x_1 + 5x_2 - 1.66x_3 + 2x_4 &= 88 \end{aligned}$$

For more detail on the relaxation method and its applications, the following references are recommended:

Allen, D N de G; *Relaxation Methods.* McGraw-Hill, 1954

Buckingham, R A; *Numerical Methods.* Pitman, 1957

Southwell, R V; *Relaxation Methods in Engineering Science.* Oxford, 1940

• • • •

Your turn—to clip out a table. That's all. But it's an important table. And behind it is a significant story pointing up gaps in our communications.

With the trend to international engineering (*PE—Oct* 2' 61) conversion tables from inches (increments of 0.0001 in.) to millimeters have not been available. This bothered the Union Special Machine Company, Chicago. Dealing with its affiliates in Europe and Japan, where units of linear measure are in metric rather than English units, the company found it necessary to provide conversion tables from zero to two inches:

"We were unable to locate such tables . . . though we checked with the US Bureau of Standards, the US Army, several engineering societies such as SAE, and quite a few of the larger corporations such as General Motors and Pratt & Whitney." As a result the company went ahead and computed its own tables.

There isn't space here for the complete set of tables* (see footnote next page), but we are presenting two that will be useful. Table 1 (below) is a readily available in.-to-mm conversion table in $\frac{1}{64}$-in. increments. It is included to allow quick conversion for nominal dimensions. Table 2 (next page) will more than cover most design tolerances you meet, from zero to 0.0499 in.

There is no possibility of human error in Table 2—once the programming was completed for the computer, each figure was calculated, rounded off, and printed by the machine. This output, in turn, has been copied directly—not reset by our printer.

It is interesting to note that three decimal places after the point in millimeter dimensions gives the same accuracy as four decimal places does in inches.

For example: Suppose the diameter of a shaft is $0.4375\ ^{+0.0003}_{-0.0002}$ in. The following table shows 11.113 mm as the equivalent of 0.4375 in. The actual

Table 1.—Inches to Millimeters (from 1/64 to 1 in.)

64ths	Millimeters	Decimals of an inch	64ths	Millimeters	Decimals of an inch
1	= 0.397	0.015625	33	=13.097	0.515625
2	= 0.794	0.03125	34	=13.494	0.53125
3	= 1.191	0.046875	35	=13.891	0.546875
4	= 1.588	0.0625	36	=14.288	0.5625
5	= 1.984	0.078125	37	=14.684	0.578125
6	= 2.381	0.09375	38	=15.081	0.59375
7	= 2.778	0.109375	39	=15.478	0.609375
8	= 3.175	0.1250	40	=15.875	0.625
9	= 3.572	0.140625	41	=16.272	0.640625
10	= 3.969	0.15625	42	=16.669	0.65625
11	= 4.366	0.171875	43	=17.066	0.761875
12	= 4.763	0.1875	44	=17.463	0.6875
13	= 5.159	0.203125	45	=17.859	0.703125
14	= 5.556	0.21875	46	=18.256	0.71875
15	= 5.953	0.234375	47	=18.653	0.734375
16	= 6.350	0.2500	48	=19.050	0.75
17	= 6.747	0.265625	49	=19.447	0.765625
18	= 7.144	0.28125	50	=19.844	0.78125
19	= 7.541	0.296875	51	=20.241	0.796875
20	= 7.938	0.3125	52	=20.638	0.8125
21	= 8.334	0.328125	53	=21.034	0.828125
22	= 8.731	0.34375	54	=21.431	0.84375
23	= 9.128	0.359375	55	=21.828	0.859375
24	= 9.525	0.3750	56	=22.225	0.875
25	= 9.922	0.390625	57	=22.622	0.890625
26	=10.319	0.40625	58	=23.019	0.90625
27	=10.716	0.421875	59	=23.416	0.921875
28	=11.113	0.4375	60	=23.813	0.9375
29	=11.509	0.453125	61	=24.209	0.953125
30	=11.906	0.46875	62	=24.606	0.96875
31	=12.303	0.484375	63	=25.003	0.984375
32	=12.700	0.5	64	=25.400	1.000

YOUR TURN *continued*

Table 2.—Inches to Millimeters in 0.0001-in. Increments (from 0.0000 to 0.049 in.)

Inch	Millimeters									
	.0000	.0001	.0002	.0003	.0004	.0005	.0006	.0007	.0008	.0009
.000	.000	.003	.005	.008	.010	.013	.015	.018	.020	.023
.001	.025	.028	.030	.033	.036	.038	.041	.043	.046	.048
.002	.051	.053	.055	.058	.061	.064	.066	.069	.071	.074
.003	.076	.079	.081	.084	.086	.089	.091	.094	.097	.099
.004	.102	.104	.106	.109	.112	.114	.117	.119	.122	.124
.005	.127	.130	.132	.135	.137	.140	.142	.145	.147	.150
.006	.152	.155	.157	.160	.163	.165	.168	.170	.173	.175
.007	.178	.180	.182	.185	.188	.191	.193	.196	.198	.201
.008	.203	.206	.208	.211	.213	.216	.218	.221	.224	.226
.009	.229	.231	.233	.236	.239	.241	.244	.246	.249	.251
.010	.254	.257	.259	.262	.264	.267	.269	.272	.274	.277
.011	.279	.282	.284	.287	.290	.292	.295	.297	.300	.302
.012	.305	.307	.309	.312	.315	.318	.320	.323	.325	.328
.013	.330	.333	.335	.338	.340	.343	.345	.348	.351	.353
.014	.356	.358	.360	.363	.366	.368	.371	.373	.376	.378
.015	.381	.384	.386	.389	.391	.394	.396	.399	.401	.404
.016	.406	.409	.411	.414	.417	.419	.422	.424	.427	.429
.017	.432	.434	.436	.439	.442	.445	.447	.450	.452	.455
.018	.457	.460	.462	.465	.467	.470	.472	.475	.478	.480
.019	.483	.485	.487	.490	.493	.495	.498	.500	.503	.505
.020	.508	.511	.513	.516	.518	.521	.523	.526	.528	.531
.021	.533	.536	.538	.541	.544	.546	.549	.551	.554	.556
.022	.559	.561	.563	.566	.569	.572	.574	.577	.579	.582
.023	.584	.587	.589	.592	.594	.597	.599	.602	.605	.607
.024	.610	.612	.614	.617	.620	.622	.625	.627	.630	.632
.025	.635	.638	.640	.643	.645	.648	.650	.653	.655	.658
.026	.660	.663	.665	.668	.671	.673	.676	.678	.681	.683
.027	.686	.688	.690	.693	.696	.699	.701	.704	.706	.709
.028	.711	.714	.716	.719	.721	.724	.726	.729	.732	.734
.029	.737	.739	.741	.744	.747	.749	.752	.754	.757	.759
.030	.762	.765	.767	.770	.772	.775	.777	.780	.782	.785
.031	.787	.790	.792	.795	.798	.800	.803	.805	.808	.810
.032	.813	.815	.817	.820	.823	.826	.828	.831	.833	.836
.033	.838	.841	.843	.846	.848	.851	.853	.856	.859	.861
.034	.864	.866	.868	.871	.874	.876	.879	.881	.884	.886
.035	.889	.892	.894	.897	.899	.902	.904	.907	.909	.912
.036	.914	.917	.919	.922	.925	.927	.930	.932	.935	.937
.037	.940	.942	.944	.947	.950	.953	.955	.958	.960	.963
.038	.965	.968	.970	.973	.975	.978	.980	.983	.986	.988
.039	.991	.993	.995	.998	1.001	1.003	1.006	1.008	1.011	1.013
.040	1.016	1.019	1.021	1.024	1.026	1.029	1.031	1.034	1.036	1.039
.041	1.041	1.044	1.046	1.049	1.052	1.054	1.057	1.059	1.062	1.064
.042	1.067	1.069	1.071	1.074	1.077	1.080	1.082	1.085	1.087	1.090
.043	1.092	1.095	1.097	1.100	1.102	1.105	1.107	1.110	1.113	1.115
.044	1.118	1.120	1.122	1.125	1.128	1.130	1.133	1.135	1.138	1.140
.045	1.143	1.146	1.148	1.151	1.153	1.156	1.158	1.161	1.163	1.166
.046	1.168	1.171	1.173	1.176	1.179	1.181	1.184	1.186	1.189	1.191
.047	1.194	1.196	1.198	1.201	1.204	1.207	1.209	1.212	1.214	1.217
.048	1.219	1.222	1.224	1.227	1.229	1.232	1.234	1.237	1.240	1.242
.049	1.245	1.247	1.249	1.252	1.255	1.257	1.260	1.262	1.265	1.267

conversion would be 11.1125 mm, but fourth-place accuracy in mm dimensions is virtually the same as asking for zero tolerances in inch dimensions.

Rounding off the mm value to $11.113^{+0.008}_{-0.005}$ mm, therefore, gives a total tolerance spread of 0.013 mm, which is equal to 0.0005 in.—the same as the original in.-unit dimension. Actually, rounding off the 11.1125-mm exact value to 11.113 mm affects interchangeability by only ⅛ of 0.0001 in.

*A special booklet of the complete in.-to-mm conversion tables is now in preparation. It will incorporate the tables given here and extend up to 1.9999 in. This important set of tables will be an exclusive contribution by PRODUCT ENGINEERING to the growing requirements of international engineering.

The booklet will cost $1.00. It will be a limited edition so reserve your copy now. On a postcard simply mark "Tables," along with your name and address. Send to Reader Service Dept, Product Engineering, 330 W 42nd St, New York 36.

• • • •

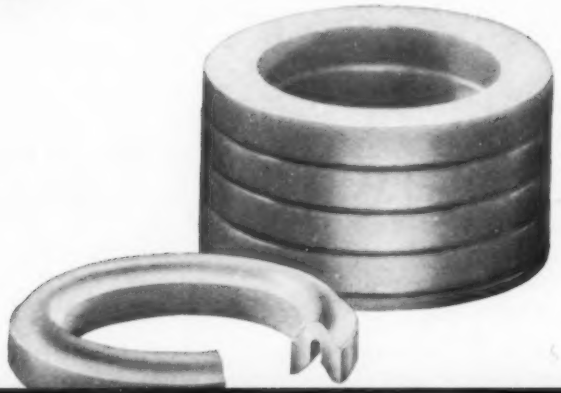
Answers to problem on p 128.

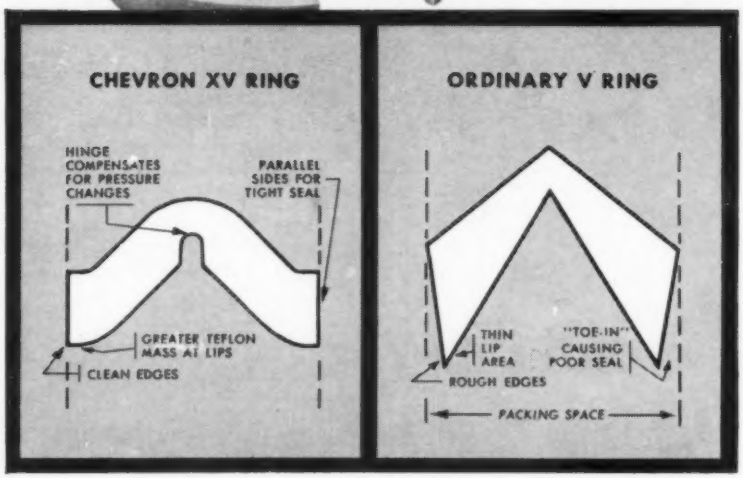
$x_1 = 3.8, \quad x_2 = 17.5, \quad x_3 = 6.333, \quad x_4 = 0.777$

NEW

GARLOCK CHEVRON* XV TEFLON† PACKING

for Hydraulic, Pneumatic Service





A new high in V-ring performance and efficiency is here from Garlock in the new CHEVRON XV Teflon Packings. Used for valves, pumps and instruments in corrosive service, this exclusive Garlock design has outperformed ordinary Teflon V-rings in rigid controlled tests. CHEVRON XV is superior in flexibility, freedom from friction, wear resistance and sealing efficiency under varying pressures—withstands pressures to 1000 p.s.i. (rings without hinges available for pressures above 1000 p.s.i.).

Can be molded precisely. The greater material mass of CHEVRON XV permits molding to consistent close tolerances ring after ring—batch after batch. Result—perfect fit, clean lips, far better sealing.

Ends frequent gland adjustment. The exclusive CHEVRON hinge compensates for pressure changes automatically. With proper installation, further adjustments are eliminated.

Greatly extends wear. Greater material mass and parallel sides give Garlock CHEVRON XV PACKINGS much more working Teflon than ordinary V-rings. Sturdier size for size, they wear considerably longer . . . yet cost you no more.

Virtually ends friction because of two factors. First, Teflon has the lowest coefficient of breakaway and running friction of any solid material in use today. Second, the exclusive CHEVRON hinge action permits free operation with minimum friction at all pressures.

Learn the full story of this superior new packing. Discuss your particular needs with your Garlock representative. Call him at the nearest of 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-192, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Co.

Order from the complete line of quality Garlock products . . . Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts.

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CIRCLE 131 ON READER SERVICE CARD 131

CUSTOM MOLDING
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TRADE PUBLIC-ATIONS
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DIRECTORY
WE DO EVERYTHING IN OUR COMPANY FROM THINKING UP YOUR PRODUCT TO SELLING IT!
MY COMPANY CAN SOLVE YOUR PROBLEMS!

Which "custom" molder is best for ME?

Molding your present product or new application in plastic or hard rubber is very often the answer to lower costs, better quality and faster deliveries—

But—**where** can you find the custom molder that will fill **your** requirements?

Although much of our competition can cite "blue chip" companies they have served for short periods, few can match the long-time, continuous, repeat business that we at

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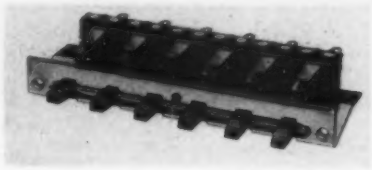
have enjoyed from our customer list of America's industry leaders.

May we show you our references and actual job samples of why these firms keep coming back for more STOKES service? **Write to Thomas E. Wallis, General Sales Manager, Stokes Molded Products, "W"-Street at Webster, Trenton 4, New Jersey.**

P.S. If you want to include a blueprint or drawing with specs, we'll arrive at your office with an estimate you'll really like!



tion momentary or locking-action types. Having a common nickel-plated brass pivot rod, assemblies are supported when installed between switch frame and mounting panel. Silver contacts are rated at 3 amp, 120 v ac non-inductive load (300 v max). **Switchcraft, Inc, 5555 N Elston Ave, Chicago 30.**

Circle 319 on Reader Service Card

Binary input decimal readout . . . requires as low as 35 milliw, using an ac motor which mounts behind panel. Numerals are 1 in. high. Motor package capable of driving eight readouts is priced at $55; delivery, 60 days. **Calibration Standards Corp, 1025 Westminster Ave, Alhambra, Calif.**

Circle 320 on Reader Service Card

Annunciator for close monitoring . . . is designed primarily for applications where it is necessary to acknowledge each alarm separately. With ⅝ x ⅞ in. frontal area, as many as 90 units can be installed in an area of 1 sq ft. Units are installed by simply snapping into punched panel, and no supporting structures are required. Annunciators also serve as press-to-acknowledge switches, with reset accomplished by means of standard pushbuttons. Window inserts are printed to customer specifications, and are available in

continued, page 134

SQUARE D NORpak

—A SIMPLER, FASTER, STATIC CONTROL!

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind.

Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers these important advantages

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

NORpak is *not* complicated—it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

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Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

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NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

Write for the complete story on **NORpak** *—its theory, application and operation...! Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin*

SQUARE D COMPANY

wherever electricity is distributed and controlled

CIRCLE 133 ON READER SERVICE CARD 133

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MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 45 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

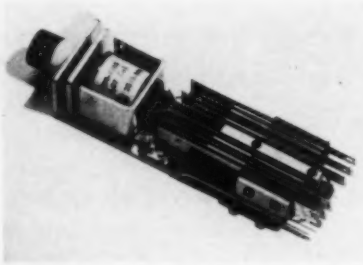
MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers . . . and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 29, MICHIGAN

translucent white, red, yellow, green, blue. **Radiation Technology, Inc, 657 Antone St, NW Atlanta 16, Ga.**
Circle 321 on Reader Service Card



Pushbutton is held in "on" position by built-in electromagnet until released by switching off holding current, which can be done manually or by separate, remotely located key. Two-color button makes position easier to determine visually. Operating voltage is 12 v dc, holding current 15 milliamp, contact carrying capacity is 3 amp, noninductive. **Components Div, International Telephone & Telegraph Corp, 320 Park Ave, New York 22.**
Circle 322 on Reader Service Card

Finger-grip pushbutton . . . has ½-in. wide protection on side of housing that provides leverage for operator of equipment requiring frequent actuation over long periods of time. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**
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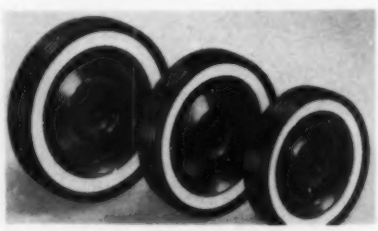
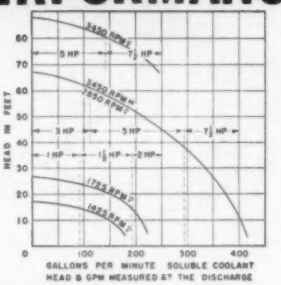


Steel wheels with white sidewalls are made in 6, 7, 8, and 10-in. OD, and 1.375 to 1.750 in. tire widths.
continued, page 136

Gusher

Coolant Pumps are

PROVED IN PERFORMANCE



Performance chart is for Model 11025

You can be sure that your GUSHER Coolant Pumps will give you year after year of highly satisfactory service. GUSHER Pumps are built to last the life of the machine they service.

Model 11025 is an immersed type Gusher Coolant pump for installations where deep tanks are necessary.

Model 11024 CM Long for pump installations requiring standard NEMA foot mounted motors to meet J.I.C. specifications. Available in ¼ HP and larger.

Gusher, fully portable, Tank Units are available in capacities from 10 to 50 gallons.

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- CIRCULATORS • AGITATORS
- MOLTEN METAL PUMPS

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Battleships are not our business, but we can make any practical size and shape forging, including cored forgings and those with bosses or cavities on two planes. (The ship model is made up from a number of production forgings.)

Special alloys are available or can be developed to meet nearly any metallurgical requirement. These include "TUF-STUF" aluminum bronze . . . "600" Series bearing bronze . . . silicon bronze . . . manganese bronze . . . aluminum alloys . . . and many, many others.

Rod for forging blanks is extruded in our own mills. We also produce our own tools and dies and maintain complete machining and finishing facilities.

You are assured quality forgings backed by the more than 45 years' experience of the world's largest producer of brass, bronze and aluminum forgings when you

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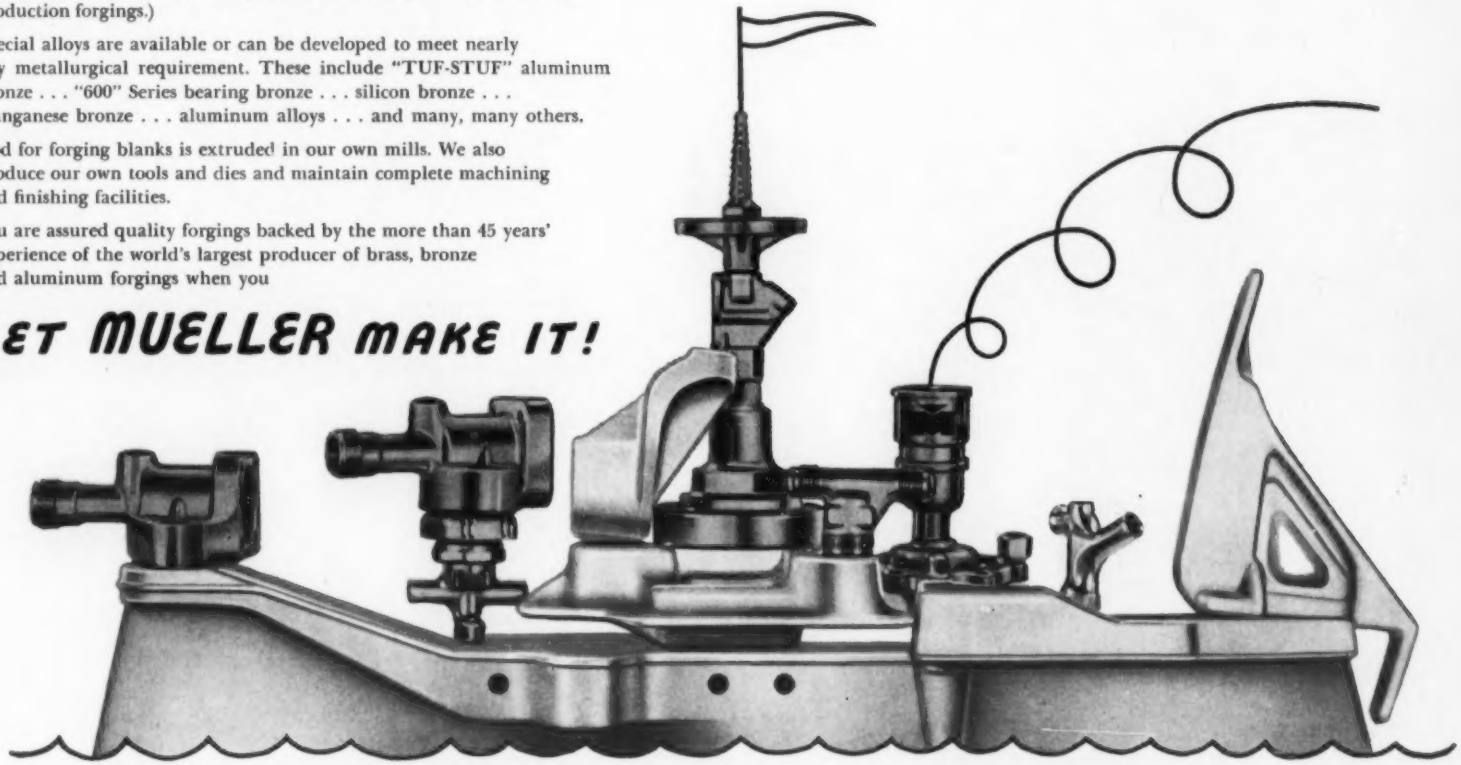

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PORT HURON 29, MICHIGAN

LETS **DINGS** DO IT

For versatile Moduline® Motocylinders:
Westinghouse *relies on*
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for fast, frequent stops

The cyclical operation of Moduline® Motocylinders, with as many as 30 thrust and return strokes per minute, demands not only instantaneous braking action but brakes with long, trouble-free service life.

That's why Westinghouse uses Dings Direct-Acting Magnetic Disc Brakes. The Dings Brakes used on Moduline® Motocylinders are estimated to be good for 200,000 to one million stops (depending on application) before adjustment is necessary.

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- No mechanical linkages to require maintenance. Easily accessible and simple to install—brakes mount on standard NEMA "C" frames. Available for horizontal, vertical or foot mounting. Easily accommodates thru shaft in all standard waterproof and dust-tight enclosures. Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment.
- Fail-safe design in event of power failure. • Standard drip-proof, waterproof or dust-tight enclosures. • Hazardous location brakes UL approved.

To help solve your specific brake problems, call on Dings complete engineering service.

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A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.
4715 West Electric Avenue
Milwaukee 46, Wisconsin

DD-261

Bearings can be of sintered, ball or roller type. **Swift Mfg Co, Inc, 13595 Helen St, Detroit 12.**
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Tensioner and idling sheaves . . . pulleys and sprockets are equipped with needle bearings and available in 18 sizes, with hardened and ground shafts 2, 3 or 4-in. long. **Brewer Machine & Gear Co, 1441-43 N 2nd St, St Louis 6.**
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Air control valve . . . with 100 psi supply can fill or exhaust its 12 cu in. load chambers in 0.125 sec (for 100 cu in. capacity, time is 0.66 sec). Of aluminum construction, solenoids require only 7.7 w. Measures 3 11/32 x 1⅞ x 3⅞ in. high. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**
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Elastomer vibration isolator . . . is said to provide up to ½ in. static cushion (deflection), as compared to typical rubber-in-shear units which can handle as much as ¼ in. 12 sizes and durometer ratings can be used for loads of 10 to 5000 lb. **Korfund Co, Inc, 19G Cantiague Road, Westbury, NY.**
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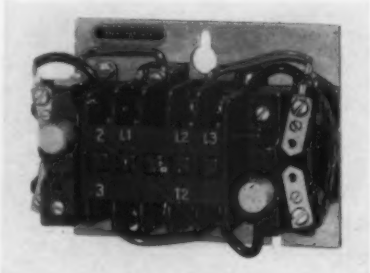

Size 00 starter . . . for general purpose motor applications of 2 hp and less is a non-revers-

continued, page 141

So gentle it won't chip china, yet powerful enough to bend steel tubing as if it were a soda straw. In a nutshell, this demonstrates the almost unbelievable degree of control built into Logan air-draulic devices.

The controlled accuracy gives this equipment a versatility and flexibility that makes it adaptable to all kinds of jobs, ranging from precision laboratory assignments to actual production line work.

If you would like additional information about air-draulic devices or other Logan products, merely fill in the coupon below.

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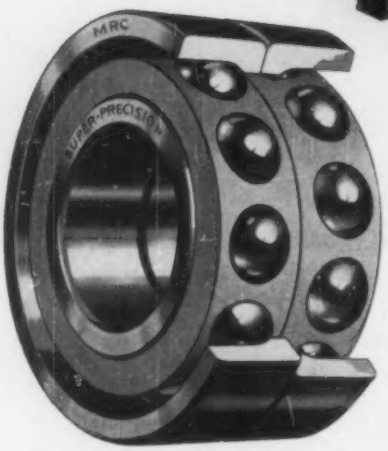

MRC pioneered, developed and produces Super-Precision Ball Bearings for high speed and to provide the ultimate in accuracy and load carrying capacity.

MRC Super-Precision Ball Bearings contribute to the reliability and accuracy of the all new Landis 14" LR Universal Grinders.

These bearings are used in the headstock and wheel feed — in this, the most accurate grinder ever produced by Landis Tool Company for medium production runs, as well as tool work.

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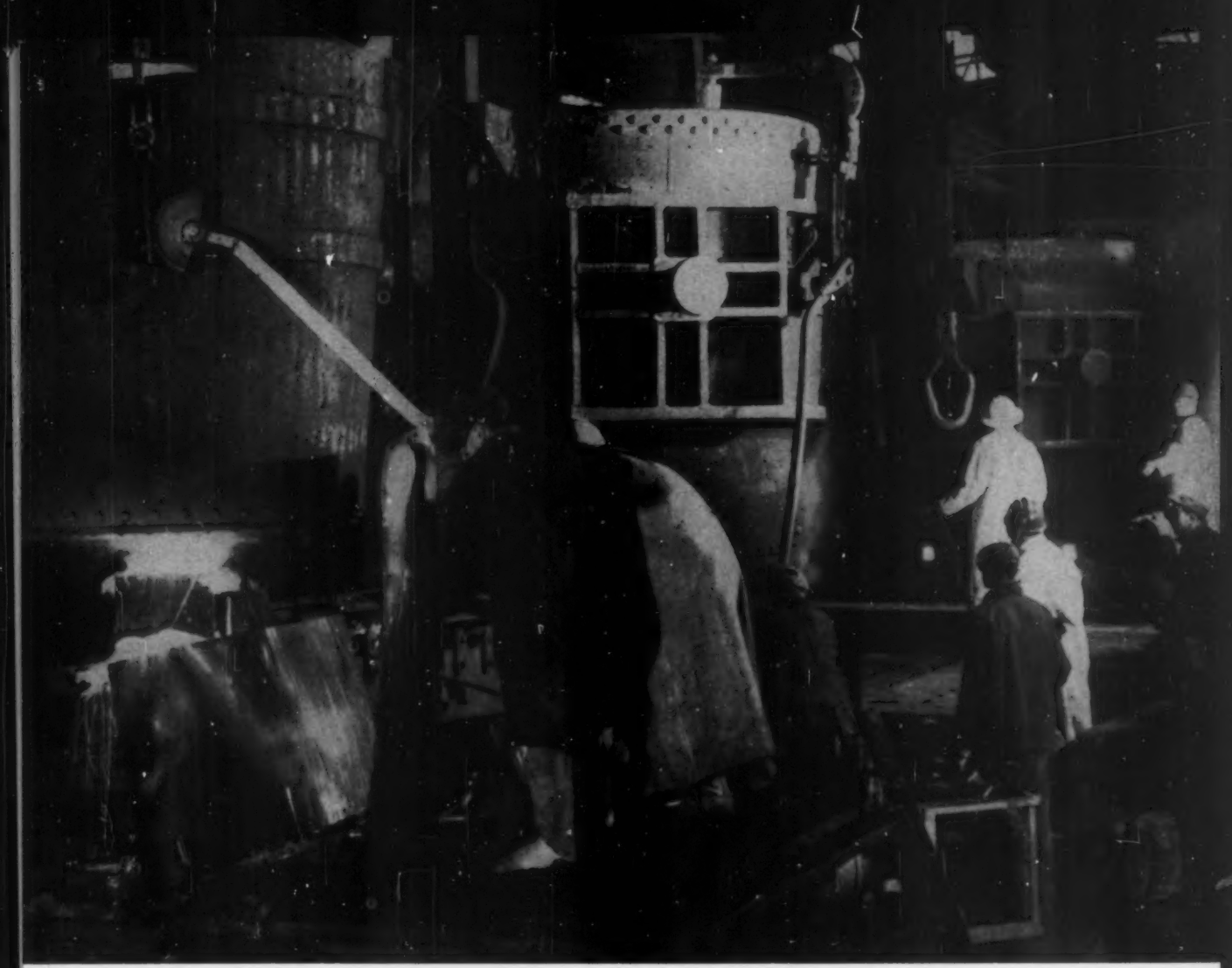


Specification steel making in Blaw-Knox Steel Foundries gives your product physical properties for maximum service

To insure the physical properties necessary for the service requirements of your product, Blaw-Knox maintains facilities for specification steelmaking including the regularly used mixes of carbon steels as well as special alloys such as molybdenum, chrome, nickel, and vanadium grades.

Ten acid open hearths, ranging in capacity from 10 to 70 tons, and two electric furnaces are available to produce exact quantities of many different grades of steel for many different castings at the same time. In some cases, as shown, huge castings weighing up to 300,000 pounds are poured simultaneously from three ladles.

Steelmaking to your order, in large or small amounts, is another part of Blaw-Knox Steel Casting Service that adds value to your product. And there's good reason why. Blaw-Knox, one of the world's leading manufacturers of rolling mills and industrial machines, knows how to keep an eye on the end-use conditions of a steel casting, make it for maximum service.

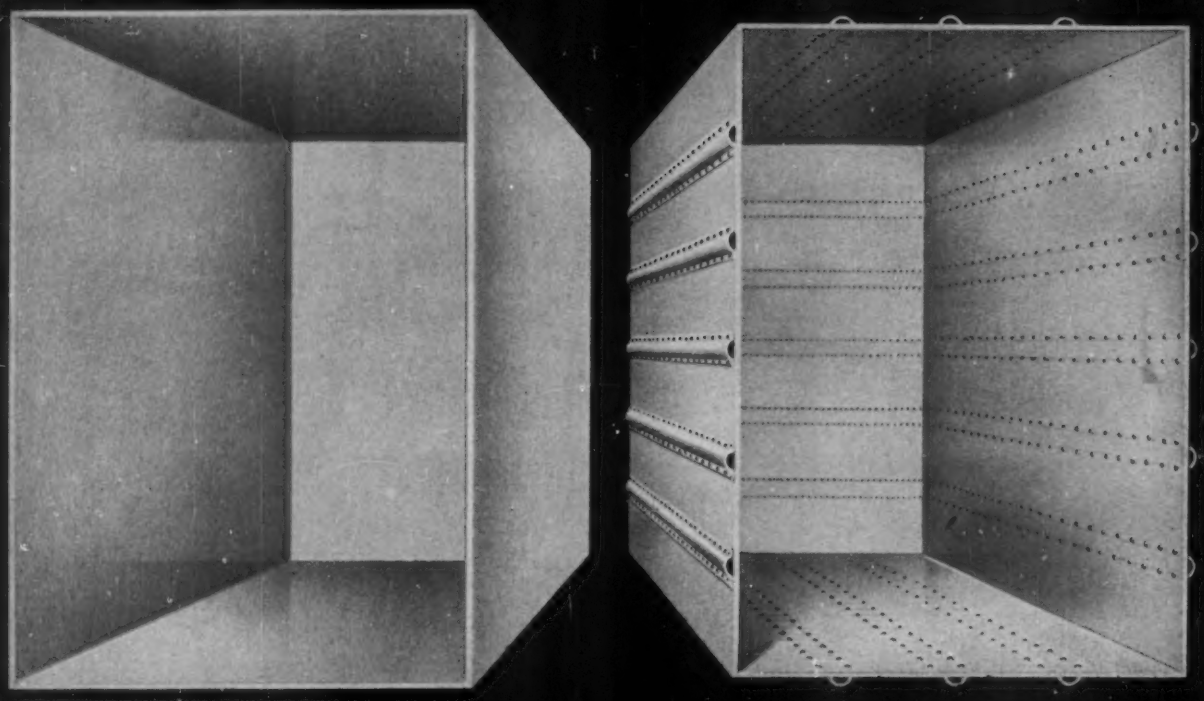
If you design or build products using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like you to have a copy of our brochure detailing Blaw-Knox Steel Castings Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

This intricate pipe line booster compressor housing was cast and machined at a Blaw-Knox Foundry. Test pressure 1800 p.s.i.—working pressure—1500 p.s.i. Weight—20,000 pounds.

BLAW-KNOX

Steel Castings

CIRCLE 139 ON READER SERVICE CARD



NO-RIB RIBBED

Thick-gauge magnesium sheet is so rigid that time-consuming rib stiffeners and fasteners are eliminated. Yet the magnesium panels are light and strong, resist dents and punctures better than thin-skinned ribbed construction.

WHICH HIGH-STRENGTH DESIGN WEIGHS LESS... COSTS LESS TO BUILD?

Magnesium no-rib, of course. By increasing the sheet thickness slightly, designers of containers and vehicle bodies get a tremendous boost in rigidity, thus can eliminate stiffening ribs. And since magnesium is the lightest structural metal, the resulting unit weighs less than conventionally-designed structures using other metals. (No-rib design in other metals introduces a severe weight penalty.) Magnesium no-rib structures are smooth-walled, minimize crevices for water seepage, have greater cubic capacity pound-for-pound than ribbed units. For detailed information on using magnesium no-rib construction for fabricated units of all types, write THE DOW METAL PRODUCTS COMPANY, Merchandising Department 1108DZ12-11, Midland, Michigan.

DOW MAGNESIUM MILL PRODUCTS

THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

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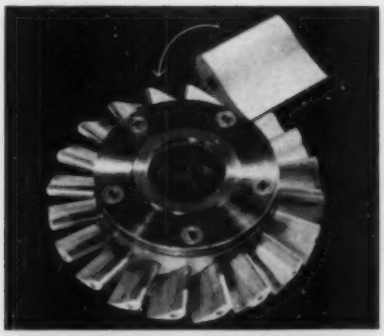
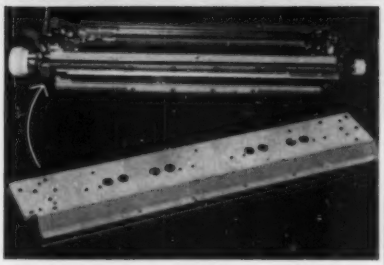
THESE EXTRUDED PRECISION PARTS NEED NO MACHINING!





(above) Automotive transmission stator blade.
(below) Electric typewriter carriage part.

These parts are made from Dow precision magnesium extrusions. They required *no machining* because of close as-delivered tolerances. Such precision parts need only end trimming or cutting to length. Where transverse holes are required, only drilling and tapping are needed.

Dow precision magnesium extrusions provide tolerances as close as ±.001 on critical cross-sectional dimensions, plus dimensional stability and light weight. Because machining is not needed, production costs are reduced. Precision magnesium extrusions like these are ideal for office machine parts, power-train components, and other precision equipment.

Complex extruded parts can be produced with consistent precision fits. Extruded shapes may include sharp V's, thin notches and accurate serrations. For information, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1153DZ12-11.

DOW MAGNESIUM MILL PRODUCTS

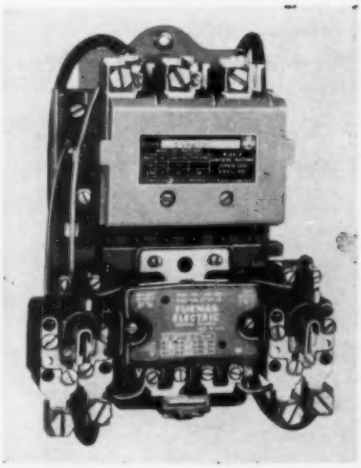
THE DOW METAL PRODUCTS COMPANY
Division of The Dow Chemical Company

ing magnetic unit with max rating of 2 hp at 440/600 v. Available as three-pole device or in NEMA 1 enclosure with two or three snap-action bi-metallic disk-type thermal overload relays. **Westinghouse Electric Corp., Standard Control Div, Beaver, Penna.**

Circle 328 on Reader Service Card

Relays with 2 through 8 poles . . . occupy same amount of panel space and butt together in rows so that wiring duct fits over all terminals. Contacts are said to be convertible in seconds without removing screws, wiring or adding parts. Coils can also be changed without removing wiring. Visual indication of operation is provided and all relays are manually operable. Rated 10 amp, 300 v. **Square D Co, Dept SA, 4041 N Richards St, Milwaukee 12.**

Circle 329 on Reader Service Card



Magnetic starter . . . available for two, three or four-pole applications has inherently trip-free thermal overload relay with visual

continued, page 142

DISCONNECTS

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GASES
FLUIDS

For fast easy connecting and disconnecting of supply lines, use—

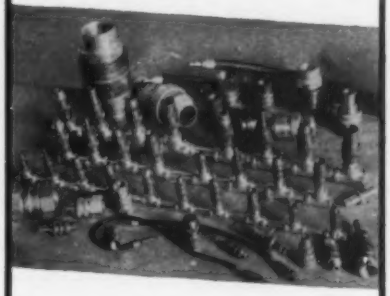
PSC DISCONNECTS

The most economical way to make or change set-ups. Fast, simple one-hand operation permits connecting or disconnecting in seconds. Just "plug in," automatic locking forms a positive leak-proof connection.

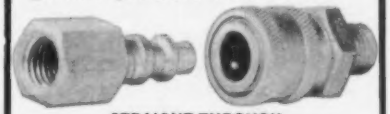
INSTRUMENT–AIRCRAFT–INDUSTRIAL

SERIES "A"—small, compact, one-hand operation. Fast, automatic action—no turning or twisting necessary.

SERIES "D"—Interchangeable with popular makes. Reduces costly Coupling inventories. The same trouble-free construction as Series "A". Automatic locking. Positive sealing.



DISCONNECTS available in many types and sizes for most media, for instrument, missile, aircraft and industrial applications. Permits making and changing set-ups instantly. Cut set-up time—get more production time.



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SERIES "E"—full flow permits unrestricted flow of media. Same inside diameter as nominal pipe or supply hose. Fast, economcal transfer of liquids or gases. Positive sleeve-locking action.

DOUBLE SHUT OFF

SERIES "G"—two-way check valve stops the flow from both socket and plug when disconnected. Ideal for fast pressure-loading of gases and industrial fluids. **PUSHOMATIC®** one-hand operation.

PSC Disconnects shipped from stock. Ask for **BULLETIN 1475** listing types and sizes—working pressures and other engineering data.

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FULTON SYLPHON DIVISION

Knoxville 1, Tennessee

trip indicators. Encapsulated magnet coils with built-in terminals of the dual voltage, dual frequency type, for 110/220 and 220/440 v, 50 or 60 cps. **Furnas Electric Co, 1050 McKee St, Batavia, Ill.**

Circle 330 on Reader Service Card

Foot or palm-operated switch . . . is 5-in. dia and intended for use as emergency stop or multi-switch starting. Available with following contact arrangements: one normally open—one normally closed; two normally open—two normally closed. NEMA 1 enclosure has die-cast case and button, with bellows-type seal. **Cutler-Hammer 315 N 12th St, Milwaukee 1.**

Circle 331 on Reader Service Card

Subminiature snap switch . . . is driven by self-energized spring and is designed to carry current loads as high as 10 amp. Rated service life is said to be more than 1 million operations. Temperature range, 100 F to 250 F. Contact arrangement, SPDT. **US Switch Corp, 7 Jefry Lane, Hicksville, NY.**

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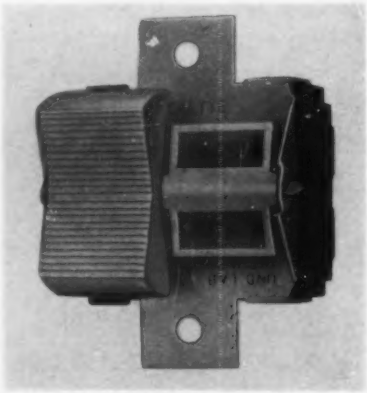
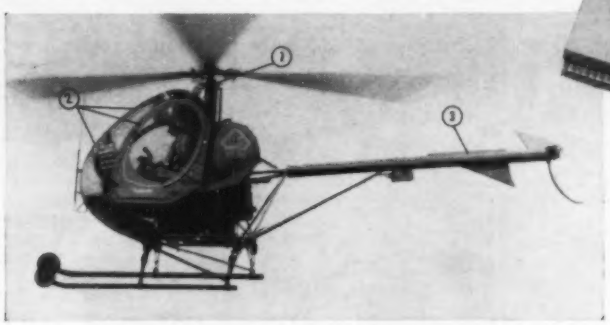


Switch for mounting behind panel is for those applications where it is important that switch not be operated by mistake, such as in voltage selection

continued, page 147

Hughes 269A compact, low-cost helicopter, designed and mass-produced by Hughes Tool Co., Aircraft Division, Culver City, California, utilizes extrusions of rigid Geon manufactured by Ryko Products, Inc., Los Angeles. Portions of Geon extrusions are shown inset: ① aerodynamic shape is part of slat across cabin top; ② flat, notched sections contain and seal plastic canopy; ③ T-shaped section is part of tail boom spoiler. B.F. Goodrich Chemical Company supplies the rigid Geon vinyl resin.



Now even helicopters go "compact"– low-cost design features rigid Geon

The manufacturer of this helicopter had a special design problem: how to save weight and cost while meeting the tough design requirements of aircraft. Engineers found the answer in rigid Geon vinyl. Lightweight and accurate extrusions of rigid Geon helped keep costs down. At the same time, their strength and resistance to weathering made them structurally and aerodynamically ideal.

Rigid Geon vinyl extrusions are used to join—and seal—sections of the acrylic "bubble", as well as for door frame retainers. Other extrusions form the aerodynamic slat across the cabin top and the tail boom spoiler.

Here's another excellent example of the way that rigid Geon improves a product, reduces weight and costs. To get more information, write Department NO-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

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Geon VINYLS

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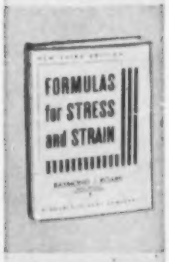

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PE-12-11

the LEAD newsletter

Vol. 3 No. 5

From the number of new battery-powered products making the headlines of late, one might conclude lead-acid batteries had just been discovered. What *is* being discovered is that while lead-acid batteries themselves go back 100 years, they've gone through tremendous changes in the past decade. In fact, design and purchasing decisions based on performance data only five years old can be radically misleading. Here are some battery re-assessments which promise new dividends to manufacturers.

Soon: A Battery-Powered Family Car

Since much family driving is short-haul, stop-and-go, Stuart Motors, Inc., Kalamazoo, figures many would like a compact auto that doesn't use any fuel when stopped at lights, requires no shifting of gears, and has mechanical parts that are simple and very few. These features have been combined in the new battery-powered Stuart car soon to be available across the country.

The Stuart will be recharged by plugging into a 110-volt household outlet. One charge will power the car for about 35 miles – a short range by gasoline standards, but more than the daily mileage most family cars run up in typical suburban operation. Top speed of the Stuart is about the legal limit where most such driving is done. Because batteries take little space, the Stuart offers lots of usable room in its 10-foot length. That running cost will be amazingly low is amply evidenced by battery-powered vehicles already in commercial operation.

Truck Fleets Prove Economy of Batteries

An Atlantic City dairy tested electric trucks on typical routes, found the cost of "fuel" (recharging of batteries) was about 2.5¢ a mile. Cost of gas and oil for identical runs was 3.66¢. Another test in Ohio showed 1.5¢ a mile for electric trucks against 7.7¢ for gasoline. One reason: on the average home delivery route, gasoline-powered trucks spend much time idling at the curb, get only four to five miles to the gallon.

These tests and others also indicate much lower maintenance costs with electric trucks – about $210 a year, against about $640 a year for gasoline trucks, not counting major overhauls.

Other costs are lower, too. There's a $35 saving on license plates, for instance, in Pennsylvania. Smooth starts reduce tire costs as much as $100. And because an electric truck is "off" when it is stopped and can't run away, insurance rates are lower – $263 to $420 in a typical case.

Boats are a Market, Too

Battery-powered boats have plied St. Louis' Forest Park lagoon for most of the years since the Fair of 1904. This summer the fleet was replaced. Lead-acid batteries still provide the power, but the boats have several new features. One of note is a sea-going species of "power steering" to which electric propulsion is particularly adaptable. The one-third horsepower motor with propeller attached is mounted underwater on a vertical shaft through the hull. The whole assembly moves when the steerman turns the wheel. There is no rudder. Thrust from the waterproof motor does its work without the slue and yaw that's usual with small craft. Steering is positive, more like that of a car – which most Forest Park seamen are more accustomed to running.

This kind of maneuverability should be welcome in other small craft. Combined with the quietness of battery power, fishermen especially should go for it.

Quiet Mowers Win Loud Acclaim

A battery-powered lawn mower introduced in England a year ago is cutting a wide swath in markets formerly monopolized by gas-powered and electric cord machines. Its quick success has been duplicated state-side by another independently developed here. Within weeks of its announcement, the maker had received 5,000 orders. He expects to produce 20,000 by next spring.

Offered in both rotary and reel types, battery-powered mowers are considerately quiet – no sound but a soft whirr of blades. Two cents' worth or so of utility current is enough to manicure 15,000 sq. ft. of lawn. With no combustibles to store, no extension cord to trip up on or get cut, safety is another welcome feature.

* * *

There is much that's new in batteries – and lead applications in general. For technical information and assistance in the product areas that interest you, simply write to Office of Technical Information, Lead Industries Association, 292 Madison Avenue, New York 17, New York. 3167

LOOK AHEAD WITH LEAD

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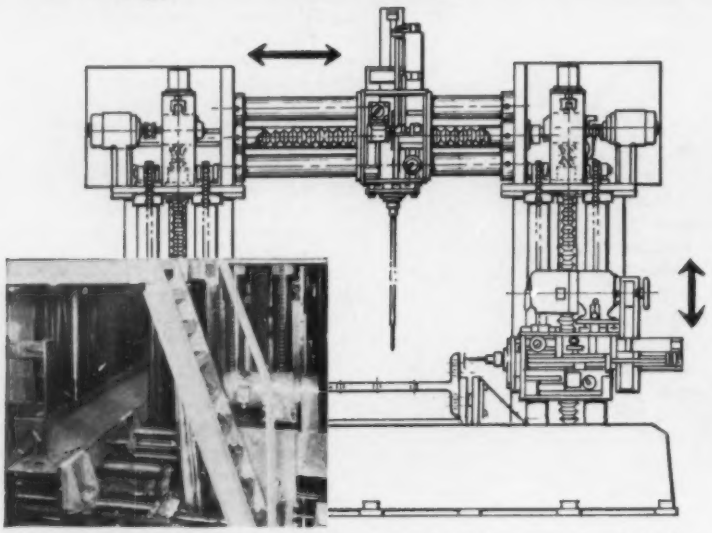
Beaver Ball Screws help Mahon save 85% in drilling holes in bridge beams, columns



Close tolerance positioning of massive 1½" capacity vertical and horizontal drill heads is accomplished with Beaver ground-thread ball screws in this new, numerically controlled drilling machine, first in the structural steel industry.

Walter P. Hill, Inc., designed and built the machine for The R. C. Mahon Co., Structural Steel Division

In addition to the important drilling cost savings, it offers repeatability in hole pattern accuracy within ±.005" as compared with ±⅛" by conventional methods and eliminates costly hole reaming in final assembly.

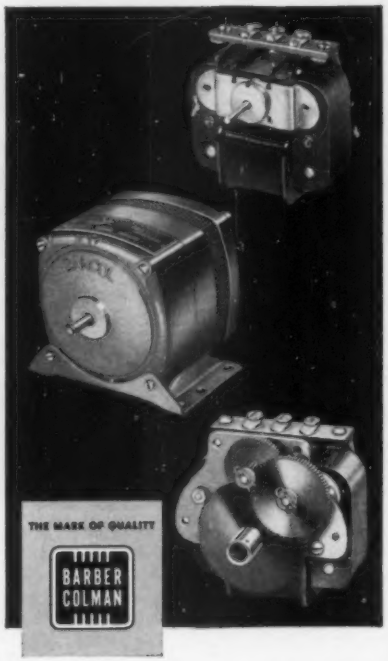
If you are considering data control, Beaver ball screws will give you the power efficiency, positioning control and compactness you need. Our engineers will be glad to work with you just as they did, in this case, with the Walter P. Hill designers.

Beaver Precision Products INC.
CLAWSON, MICH.

146 CIRCLE 146 ON READER SERVICE CARD

High-torque, fast-reversing Barber-Colman a-c motors

(with or without gearheads)



Ideal for low-cost servo systems utilizing either transistor or vacuum-tube control, these compact, powerful shaded-pole motors are adaptable to a variety of electronic control circuits. In many systems they satisfactorily replace motors costing twice as much. Adaptable to split-phase capacitor operation . . . available with open or enclosed gear reductions . . . 2-phase or electronic control windings. Ratings are from .00015 to .04 hp. Fast-reversing low-inertia rotors . . . high starting torque . . . electrodynamic braking . . . quality guaranteed!

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Gives typical specifications on the complete line of Barber-Colman a-c small motors: unidirectional, synchronous, reversible • With or without reduction gearing • Open or enclosed types Stator and rotor sets also available.

BARBER-COLMAN COMPANY
Dept. X, 1212 Rock St., Rockford, Illinois

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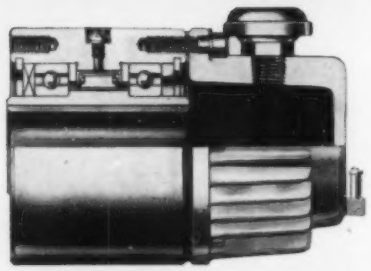

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FORMSPRAG COMPANY
23607 HOOVER ROAD, DEPT. 125
WARREN (DETROIT), MICHIGAN
Precision Power Transmission Products

in heavy duty equipment. Operation is by screw driver inserted through slots in protective panel. **Cutlet-Hammer, 315 N 12th St, Milwaukee 1.**
Circle 333 on Reader Service Card

Two-way solenoid valve . . . measures 2-17/32 in. high and has face-to-face measurement of 1⅜ in. Packless and normally closed, valve is made with either Delrin or brass body. For ⅛ and ¼-in. pipe connections and 3/32 in. orifice. Continuous duty, Class A coils, rated 5 w ac, available in most standard voltages. **Automatic Switch Co, Florham Park, NJ.**
Circle 334 on Reader Service Card

Remotely adjustable relief valve . . . consists of pilot-operated valve and a 115-v ac electric motor actuator that turns an eccentric cam, which in turn extends or retracts a plunger. Plunger alters compression of valve's control spring, thus changing line pressure required to open valve. Desired pressures are set by limit switches in actuating motor for any two settings up to 5000 psi. Available in ¾-in size. **Double A Products Co, sub Brown & Sharpe Mfg Co, Manchester, Mich.**
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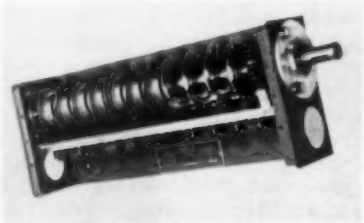
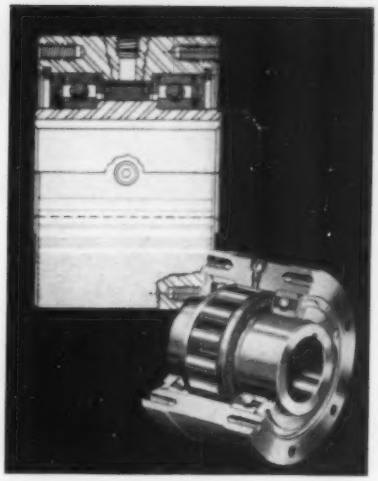


Multiple split-lobe cam switch . . . is adjustable for on-off time by means of individual dials on each cam assembly. Repositioning of individual lobes in each cam assembly alternates cycling of machine functions or processing steps at fixed intervals. **Gemco Electric Co, 25685 W Eight Mile, Detroit 40.**
Circle 336 on Reader Service Card

Solid-state time delay . . . elements are available in fixed or variable units, to operate from 50 microsec to 500 sec at standard accuracies of 2%, 5% and 10% over any combination of 18 to 31 v dc and at −55 C to 125 C. Variable units may be adjusted over 30:1 range by means of

continued on page 149



For indexing rates to 1200 strokes/min.

HPI Clutches

Whenever indexing requirements exceed 150 strokes per minute or 90° per stroke, then Formsprag HPI clutches present the ideal solution. Proved the finest indexing clutch on the market today!

- Torque capacities from 140 to 13,500 lbs. ft.
- Bore diameters from .500″ to 6.000″.
- More torque for a given size and weight.

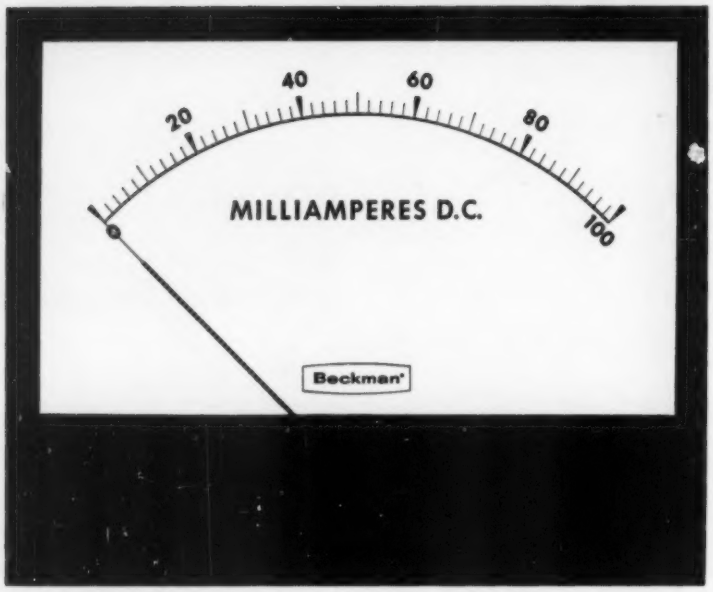
Write for Formsprag Catalog 105B

FORMSPRAG COMPANY
23607 HOOVER ROAD, DEPT. 124
WARREN (DETROIT), MICHIGAN
Precision Power Transmission Products

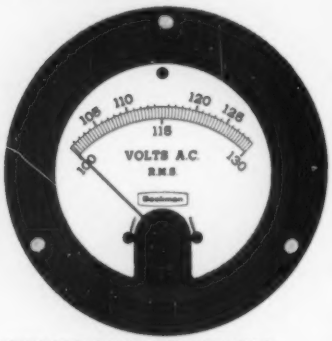
CIRCLE 64 ON READER SERVICE CARD

CIRCLE 147 ON READER SERVICE CARD

NOW...THE RIGHT ANSWER TO YOUR METER PROBLEM HAS A CLEAN NEW LOOK!



STANDARD PANEL METER
4" x 6" size, 0-100 Milliamps



EXPANDED SCALE AC VOLTMETER
3½" Ruggedized and Sealed

COMMERCIAL PANEL METERS
Beta ray indicator–4½"

Here's the clean, uncluttered look in meters–handsome appearance, sensible proportions. These meters are precision-built by Helipot–every one ruggedly constructed for lasting accuracy. All-metal frames, gasket sealed, steel movement enclosures, glass windows.

Whatever your meter problem, you'll find the right answer at Helipot; nearly 600 standard models that can be readily customized for your application. For routine metering jobs or for the most unique ranges and purposes–custom scale plates, special expansions, special calibration accuracies, multiple range meters. You name it.

You get faster service at Helipot. Standard models are shipped in 30 days, specials in only 45 days.

And you get better, more convenient service. At Helipot, the smallest order receives the same consideration as the largest. And the entire job can be handled through your nearest Helipot Sales Engineering Representative. Call him or write directly to Helipot for more details. Your meter problems are as good as solved!

Beckman INSTRUMENTS, INC.

HELIPOT DIVISION
Fullerton, California
POTS : MOTORS : METERS

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GREAT HISTORICAL LEAKS

BETTER WITH A SEELSKREW*

SEELSKREWS*, SEELBOLTS* and SEELRIVITS* are high-pressure, self-sealing, vibration-resistant fasteners for critical military and industrial applications. They are dimensionally interchangeable with standard fasteners, and maintain tensile, torque and shear strength of standard non-sealing fasteners.

We also make:

HEXSEALS*

Modular external seals that fit onto switches, potentiometers, circuit breakers and lighted push buttons.

APM PRODUCTS MEET ALL APPLICABLE MIL SPECS.

Our list of modular seals is just too long for this ad. Let us send you our Catalog No. 359B.

*Trade Mark

Write or call: **MISS RIVA SOLINS**

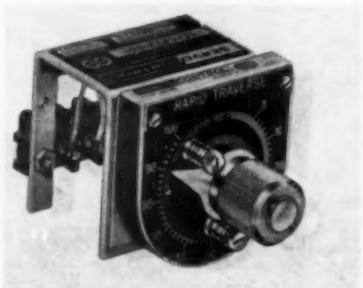
APM HEXSEAL CORPORATION
41 Honeck Street, Englewood, N. J.
LOwell 9-5700

external resistors or potentiometer. May be turned on or off, before, during or after timing cycle, held off or externally synchronized, permitting logical operation. One series provides 100 ma output at rated voltage, the other, 2 amp relay output. **Logitek, Inc. 54 Rome St, Farmingdale, NY.**

Circle 337 on Reader Service Card

Fhp gear motor . . .
develops to 30 lb-in. torque for continuous duty, Powered by two-pole, shaded pole, unidirectional induction motor, which operates on 115 v, single phase, 60 cps, ac current. Available with braking, cooling and other special modifications. **Merkle-Korff Gear Co, 213 N Morgan St, Chicago 7.**

Circle 338 on Reader Service Card



Potentiometers for heavy-duty . . . control functions are oiltight, accomodate single or multi-gang units and fit into NEMA, JIC or UL enclosures or commercial control stations. Potentiometer resistance, 2500 ohm, 1 w at 65 C. Single-turn preset, 10-turn rotating dial reset, and 10-turn digit counter preset units are available. **Oilgear Co, 1570V W Pierce St, Milwaukee 4, Wis.**

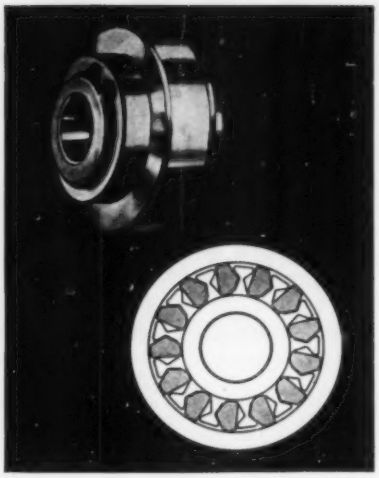
Circle 339 on Reader Service Card

Long stroke, rolling diaphragms . . . are designed to provide an effective pressure area that remains constant throughout stroke. Low pressure diaphragms made of Buna N, neoprene, GR-S, butyl, silicone, Hypalon, polyurethane, Viton or a fluorinated silicone are available—also reinforced with such materials as Dacron, nylon, Teflon, glass fiber for high pressures. **Diaphragm Industries, Inc., 102 Rontoul St, Beverly, Mass.**

Circle 340 on Reader Service Card

Vane-axial blower . . .
is 2 in. dia, delivers 37 cfm at 1.5 in. H_2O back pressure at 16,500 rpm, using 26 v dc. Housing and shroud are

continued, page 151



Miniature Clutches

FOR INDEXING, OVER-RUNNING, BACKSTOPPING

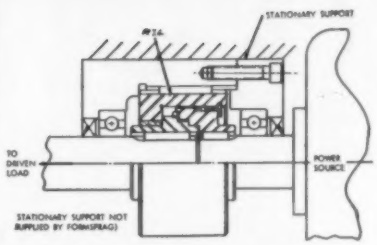
Two models offer high continuous over-running speeds (FS-02 to 3450 rpm and FS-04 to 2400 rpm) and indexing rates up to 5,000 cycles per minute—15% higher than previous models.

- Model FS-02 has 4.5 ft. lbs. torque capacity with 250" bore and Model FS-04 has 17 ft. lbs. with .375" or 500" bores—tops for their size and weight.
- Each sprag is individually energized, insuring ultra-high performance.
- Gears, sprockets, etc. can be mounted to either outer race hub or to outside diameter of clutch.

Write for Catalog 105B

FORMSPRAG COMPANY
23607 HOOVER ROAD, DEPT. 126
WARREN (DETROIT), MICHIGAN
Precision Power Transmission Products

CIRCLE 66 ON READER SERVICE CARD



Reverse Locking Clutches

FOR POSITIVE LOAD POSITIONING

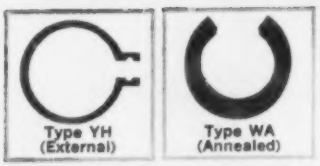
Sketch above shows why the load "stays put" once the power source is stopped. Any possible motion of driven load is arrested by R-L clutch acting on the stationary support.

- There is no backlash or feedback torque in this high precision device.
- Long life is assured by high efficiency sprags.
- Simplicity of design means minimum number of moving parts.
- Compact units for torque capacities from 40 lbs. in. to 30,000 lbs. in.
- Bores and shaft sizes range from ¼" to 2½".

Write for R↕L (reverse locking) literature

FORMSPRAG COMPANY
23607 HOOVER ROAD, DEPT. 127
WARREN (DETROIT), MICHIGAN
Precision Power Transmission Products

CIRCLE 149 ON READER SERVICE CARD

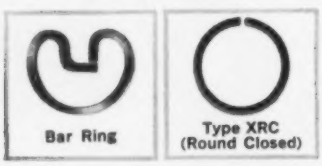


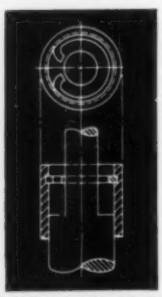
...Improve Product Quality!
...Lower Production Costs!

NATIONAL RETAINING RINGS

Call or write for catalog or ask for recommendations on specific applications

Eliminate machining time and material waste resulting from cutting down shafts and housings to form shoulders. Using smaller shafts, grooved to accommodate economical NATIONAL Retaining Rings, accomplishes important cost reductions, speeds-up production, actually improves the product. Proven applications range from heavy duty machinery to small tools, electronic instruments and toys.

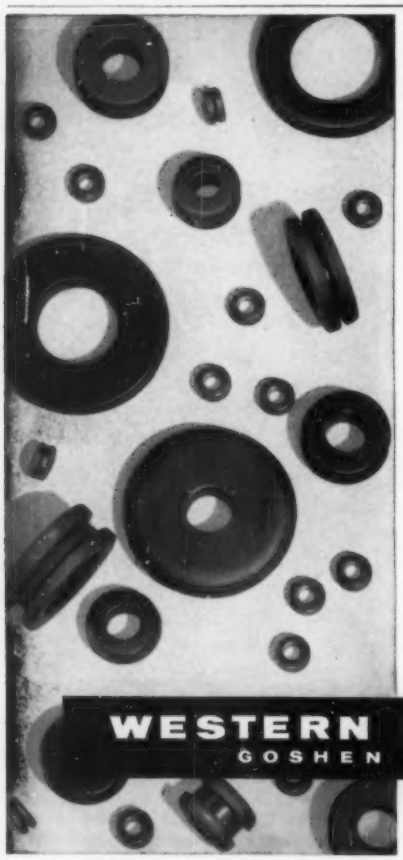


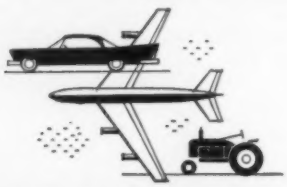


The NATIONAL LOCK WASHER COMPANY
MILWAUKEE 2, WISCONSIN
NEWARK 5, NEW JERSEY

Serving Industry Since 1886

CIRCLE 67 ON READER SERVICE CARD





GROMMETS
...by the Millions

Grommets for any conceivable industrial purpose from natural, all purpose (GR-S), Neoprene and Buna-N rubbers.

Western grommets come in hundreds of standard sizes, and can be ordered in any formulation from molds already prepared.

Western Rubber is fully equipped for production of either standard or custom designed grommets in any size, shape or volume. All are quality controlled and economically produced to your specifications.

Write or phone for information or a visit by our sales engineer in your area.

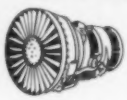
SINCE 1902

WESTERN RUBBER CO.
GOSHEN 3, INDIANA

MOLDED AND LATHE-CUT RUBBER PARTS FOR ALL INDUSTRIES

LOOK AT WHAT YOU CAN DO WITH MODERN TORQ SPEED DETECTORS

JET ENGINES



In event of overspeed, automatically actuate the control circuit. Torq speed switches for aircraft are temperature compensated, inherently balanced and produced to required military specifications.

SAW MILLS

Automatically withdraw cutting blade due to overload for any reason.

MACHINE TOOLS

Automatically brake and shift transmission at proper pre-determined speeds selected by push button.

METER SCALES

Automatically switch scale ranges where rotary speed is a function of the measurement.

ELEVATORS

Cut in braking circuit if unit overspeeds, or falls below operating speed due to overload.

GAS ENGINE GENERATOR SETS

Automatically switch from cranking cycle and protect against overspeed.

DIESEL ENGINES

Switch out cranking motors, engage and disengage cooling circuit, supply varying fuel requirement, signal full speed.

TRUCK REFRIGERATORS

Maintain proper alternator output at all truck speeds by automatic shifting of alternator transmission at pre-determined truck engine r.p.m.

Torq speed detectors are small, snap-acting, rotary centrifugal switches for actuating one or many circuits at one or more pre-determined speeds from 0 to 15,000 r.p.m. — they operate on speed only, independently of all other conditions — can provide up to 3 million cycles of uniform operation at tolerances to ¼ of 1% — are designed on a patented "friction-free" principle — and are available in a wide range of sizes, models and operating characteristics to meet practically any application.

Patents and Patents Pending

Write or phone for additional data.

TORQ ENGINEERED PRODUCTS, INC.
60 WEST MONROE STREET • BEDFORD, OHIO, U.S.A.
Phone: BEdford 2-4100

CIRCLE 150 ON READER SERVICE CARD

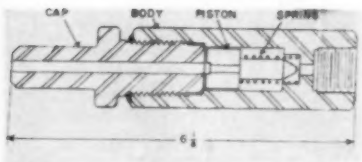
CIRCLE 68 ON READER SERVICE CARD

black anodized aluminum castings. Weight 5 oz. Can be supplied for voltages up to 50 v dc. Max current is 1.15 amp at free air delivery of 53 cfm. **Globe Industries, Inc, 1784 Stanley Ave, Dayton 4, Ohio.**
Circle 341 on Reader Service Card

Wound field dc or ac/dc motors . . . with continuous duty ratings of 1/9 hp at 800 rpm are supplied wound for series, split series, shunt or split shunt operation, to meet appropriate MIL specs. These motors can be obtained with braking, speed governing or reduction gearing. Weight ranges from 1.5 to 2.2 lb. **Globe Industries, Inc, 1784 Stanley Ave, Dayton 4, Ohio.**
Circle 342 on Reader Service Card

Engraved dials . . . fabricated from 24 ST aluminum sheet are black anodized with white-lacquer-filled figures and characters. Available with 2 to 36° increments, ½ to 4 in. dia. **Sterling Instrument, Div Designatronics, Inc, 17 Matinecock Ave, Port Washington, NY.**
Circle 343 on Reader Service Card

Dc torque motors . . . can eliminate gear trains to provide direct drive in applications requiring very high order of angular resolution and/or response at the load. Torque capacities range from 20 to 350 oz-in. Immediate delivery in production quantities. **Giannini Controls Corp, 1600 S Mountain Ave, Duarte, Calif.**
Circle 344 on Reader Service Card



Excessive flow check valve . . . was designed to shut off noxious, toxic or flammable lines in the event of failure. With only two moving parts, can be designed to provide either complete
continued, page 153

STOP!

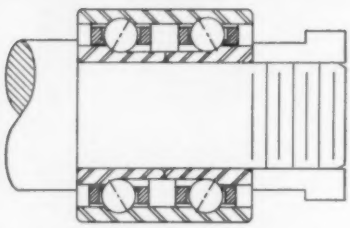
Look what happened when A. W. Haydon designed a new LABORATORY STOP CLOCK

You just won't find these features in any other stop clock. This versatile timer-of-all-work was designed by engineers who understand timers and timing...and who needed a precise time reference in their own work. **Timed outlet**—energized whenever clock runs, supplies 115V, 60 CPS, 3 amp to time and control external loads simultaneously...manually or automatically. **External Run Socket**—for remote running, using a control cable... manually or automatically (when wired into a system). **Clutchless timing mechanism**—needs no warm-up, make-ready or pre-start. Synchronous motor starts and drives instantly. No power consumed except during timing and reset. **Independent RUN and RESET** buttons for manual, local control. **Schematic diagram** and control circuitry silk-screened on bottom of housing for ready reference. ■ Bench type precision stop clocks are available with optional remote control for manual or automatic running and/or resetting. Clocks operate on commercial 115V, 60 CPS power; accuracy is ± 25 milliseconds. Low power drain: only 2 watts, timing. Sweep second scale calibrated in 10 millisecond increments; totalizer scale calibrated in seconds, up to 1 min. Sturdy instrument case requires only 4¼" square bench space. For complete specifications, write for Bulletin ET-702. Ask also about panel-mounting versions.

THE A.W. HAYDON COMPANY
221 North Elm Street, Waterbury 20, Connecticut

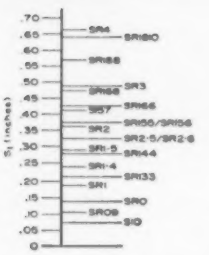
No. 4

ideas you can use in working with bearings

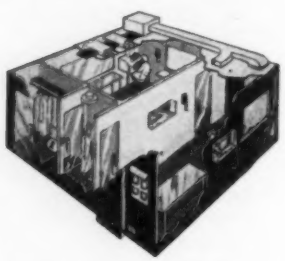


So-called "super duplex" bearings have two separable inner rings and a one-piece outer ring with two raceways which eliminates the possibility of angular or radial misalignment. Cherry-reamed ball pockets hold the balls firmly in the retainers when the inner rings are removed and make it possible to handle the outer ring, balls and retainer as a separate unit during installation in instruments.

For servomotor applications, it is necessary to use bearings of a low specified radial play in order to keep rotor shaft runout at a minimum. A radial play of .0002" — .0004" is commonly specified for such bearings. A side benefit is that low radial play will cause a maximum number of balls to share the load which is nearly always radial.

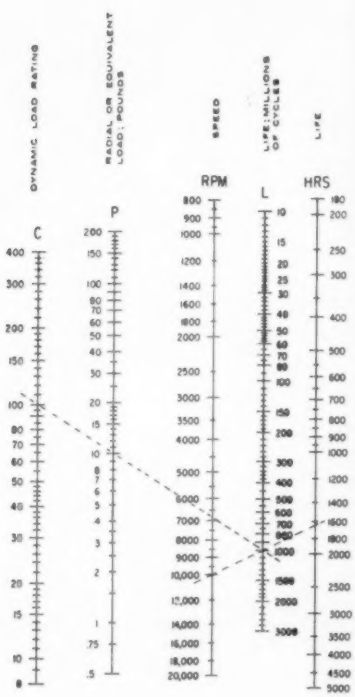


The linear speed with which bearing balls roll along the raceways is an important factor affecting bearing life, running noise, vibration and lubrication requirements. If, in selecting a bearing, the fundamental specifications have been satisfied and there is still a choice of size, a logical selection would be the one with the lowest ball rolling speed. In the chart above, ball rolling distance (S_1) x .00139 x bearing rpm = ball rolling speed in ft./sec.



To a precision miniature bearing, a speck of dirt seems like a rock. To prevent such contamination from doing serious damage in the raceways, some form of environmental control is essential when handling or installing miniature or instrument ball bearings. One form is a "clean room", essentially a dust-controlled room-within-a-room. Another is individual dust-controlled hoods. Work tables should have a smooth, non-contaminating surface such as Formica or stainless steel.

LOAD NOMOGRAPH



Load ratings of NHBB bearings provide a quick method of estimating bearing life.* Using nomograph at right, a load or "C" rating of 100 lbs. for a bearing loaded radially with 10 lbs.(P) could be expected to have a life(L) of 1,000 million revolutions assuming temperature is not a factor and the lubricant employed is adequate. At 10,000 RPM, the life would be 1670 hours. The C values for the various types of New Hampshire bearings made of stainless steel (AISI 440C) are included in the bearing tables. The C value for chrome steel bearings is approximately 1.2 times the listed value, and the C value for beryllium copper bearings is approximately one third the listed value.

150-page Design and Purchasing Manual is the most comprehensive treatise on miniature and instrument ball bearings ever published. Qualified design and specifications engineers, and procurement specialists, are welcome to a copy.

*Rating life of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops (approx. 1/5 of average life).

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

new
sealed
bearings
from
New
Hampshire

Now you can protect the life and running quality of New Hampshire bearings on applications where lubricants tend to work out and atmospheric contaminants tend to work in.

The miniature and instrument bearings listed below are equipped with positive, contact-type seals which keep lubricant in and dirt out.

BORE +.0000 −.00015	OUTSIDE DIAMETER +.0000 −.00015	WIDTH +.000 −.001	BEARING NUMBER	C RATING
.0550	.1875	.1094	SR1LL3	22
.0781	.2500	.1406	SR1-4LL3	30
.0937	.3125	.1406	SR1-5LL3	50
.1250	.3125	.1406	SR2-5LL3	51
.1250	.3750	.1562	SR2LL3	58
.1875	.3750	.1250	SR166LL3	64
.1875	.5000	.1960	SR3LL3	106
.2500	.5000	.1875	SR188LL3	97
.2500	.6250	.1960	SR4LL3	134
.3125	.5000	.1562	SR1810LL3	47

Write for complete information

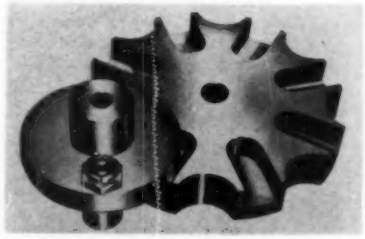
NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

closure or calibrated leak. In operation, whenever rate of flow exceeds pre-determined rate, spring-loaded poppet valve shuts off. As soon as system returns to normal pressure, valve resets automatically. **Chemiquip Co, 36 E 10th St, NY 3.**

Circle 345 on Reader Service Card

Battery-powered sequence timer . . . runs on 4.5 v "A" battery timer for 8-12 months. Accuracy is ±10 sec/day over 30 to 140 F temperature range, and is said to be unaffected by voltage fluctuation. 15-jewel driving movement has shock-mounted pivot shaft and single, double-throw switch is actuated by cam mounted on output shaft. Cams are available with 1, 2, 3, 4 or 6 lobes which will actuate switch as many times in either a 1-hr or 12-hr period. Price, $65 to $80, including any one cam. Switch closure times are adjustable. **Geodyne Corp, 180 Bear Hill Road, Waltham 54, Mass.**

Circle 346 on Reader Service Card



Geneva drives . . .
have 3 to 24 indexing stations for shaft center distances of 3 to 6 in., in ¼-in. increments. A variety of hub and bore diameters are available. Steel wheels are furnished with Meehanite driving wheels. **Genevamatic Engineering Corp, PO BOX 10386, Tampa 9, Fla.**

Circle 347 on Reader Service Card

NEW MATERIALS

Lacquer for aluminum . . .
can be colored by a separate dipping to simulate gold, bronze, brass, copper to have successfully resisted over 400 hr exposure to salt spray, 7 days exposure to fresh mortar. Lacquer air dries and can be applied by spraying or brushing. **Schwartz Chemical Co, Inc, 50-01 Second St, Long Island City 1, NY.**

Circle 348 on Reader Service Card

Spiral-wound fiberglass tubing . . . is based on epoxy resin said to have hydrostatic burst pressure of 30,000; tensile of 14,000 psi. Available in either smooth ground finish or clear dipped epoxy finish in 36 and 45-in. lengths, depending on type of tube. Standard dimensional ranges are: ID — ½ in. min, 5 in. max; ⅛ in. min wall thickness. **National Vulcanized Fibre Co, 1061 Beech St, Wilmington, Del.**

Circle 349 on Reader Service Card

Centrifugally molded fiberglass tube has tensile strength of more than 17,000 psi, can handle pressures to 150 psi, at temperatures of 165 F to 110 F (to 500 F without pressure). Available in lengths of 3 to 7 ft, 6 to 28½ in. dia. Wall thicknesses range up to ⅝ in. Made in assorted colors. **Apex Fibre-glass Products Div, White Sewing Machine Corp, Washington and Elm St, Cleveland 13.**

Circle 350 on Reader Service Card

Aluminum-clad low-carbon steel . . . in thicknesses to 0.100 in., widths to 12 in. and with aluminum layer to 50% of total thickness is used as an intermediate or transition material in welding steel and aluminum members together. Conventional welding methods and equipment are satisfactory and coated electrodes are suitable. Strength of clad metal bond is said to exceed that of solid metals themselves. Straight lengths or coils are available. Delivery, 3-4 wk. **Metals & Controls Inc, Div Texas Instruments Inc, 34 Forest St, Attleboro, Mass.**

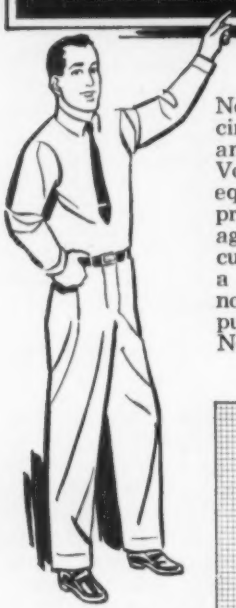
Circle 351 on Reader Service Card

One-can polyurethane coating . . . system in hard or flexible versions is available in a variety of colors and finishes. Will cure either at room temperature or at baking temperatures. Standard methods of application are suitable. **Hughson Chemical Co, Div Lorg Mfg Co, Erie, Penna.**

Circle 352 on Reader Service Card

Acme ACME Electric

CONSTANT VOLTAGE STABILIZERS PROTECT THEMSELVES AGAINST OVERLOAD!



No need to "fuse" the output circuit against overload when an Acme Electric Constant Voltage Stabilizer is part of the equipment. These stabilizers provide automatic protection against overload or short circuit. When load current reaches a critical point in excess of normal operating load, the output voltage is reduced to zero. No voltage — no current.

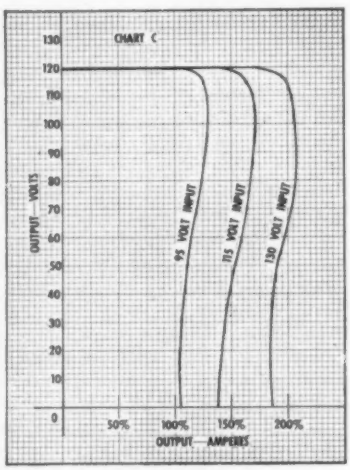


Chart shows performance curves under various voltage inputs and current overload conditions. This current limiting is accomplished automatically.

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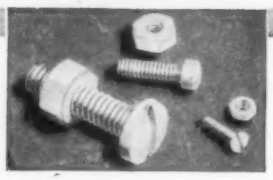

Economically mass produced on fully automatic patented machines, GRC nylon parts are available from stock in many sizes and types. GRC uses single cavity techniques, molds in one automatic cycle, gets accurate, uniform parts.

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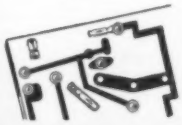

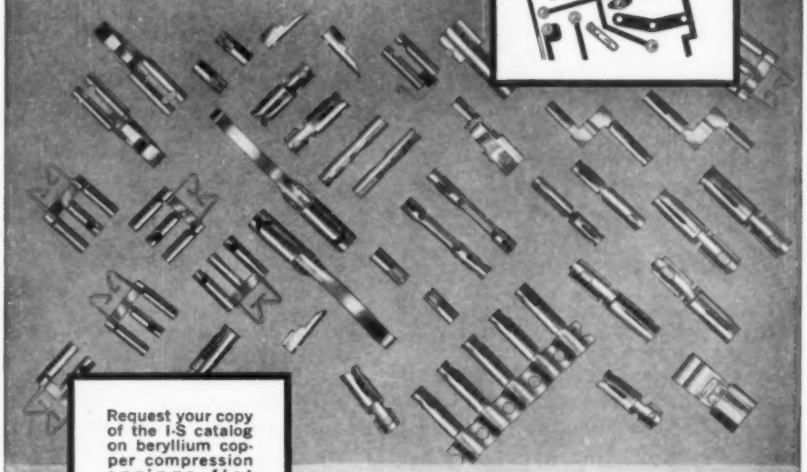

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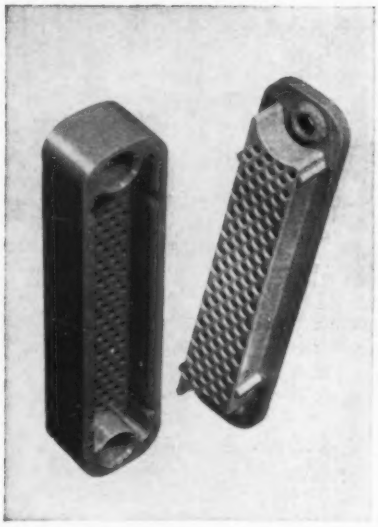

GOOD ELECTRICALS. Microminiature connector contains up to 20% more contacts in the same space, thanks to dimensional stability and good electrical properties of LEXAN resin. Self-extinguishing, the material provides low loss, good insulation resistance and a dielectric constant and power factor which are virtually independent of temperature. (Amphenol-Borg Electronics Corp.)

DESIGN LITERATURE

Spring design and application

N P CHIRONIS, Assoc Editor, Product Engineering. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36, NY. 8⅜ x 11, 348 pp. $9.50.

This manual includes spring design data, equations, and theory containing material prepared by more than a hundred authorities on the subject, it covers a variety of spring types, static and dynamic design considerations, materials, and applications of springs to machines and components.

Comprised of articles carefully selected from PRODUCT ENGINEERING and edited by Assoc Editor N P Chironis, the book brings together information necessary for designing and applying springs. It presents theory that leads to useful design equations, design details, charts, and nomographs, and, in the case of spring applications, to specific design details. Many of the articles present important concepts and frequently include current refinements in methods. Introduced are such recent developments as constant-force and multi-rate springs; ceramic, glass fiber, and plastic springs; air and liquid springs; Belleville and ring springs; flat-curved springs; flexure pivots; spring clutches; and spring belting.

Many current problems are discussed in detail, few of which have been covered previously in a single volume. These include spring buckling and unseating, surge waves, dimensional analysis of springs, spring tangling, designing for minimum fatigue and residual stresses, relaxation, creep, high-temperature considerations, shock, costs, manufacture and testing, fastening and adjusting methods, designing for linkage balancing, overload protection, and shock absorption.

Numerous detailed charts and diagrams help clarify important points and help provide a clearer understanding of the technical material presented.

An excellent working guide, this manual will help to select the spring type best suited for a particular application, and to overcome the variety of problems that face the mechanical engineer daily. It can also be a constant source of new ideas to product engineers.

Shock and vibration in linear systems

PAUL A CRAFTON. Harper & Brothers, 49 E 33rd St, New York 16. 6¼ x 9½, 415 pp. $10.00.

Based on an undergraduate course given to seniors over the past several years, this book approaches the subject of shock and vibration from the modern viewpoint of engineering science rather than that of technology. It presents a unified analytical and theoretical treatment, making full use of the operational calculus of the Laplace transform, transfer functions, mechanical impedances, and mechanical circuits. It deals fully with transient and steady-state phenomena, with no primary emphasis on the latter. No mathematical preparation beyond elementary differential equations is assumed.

Mechanics

KEITH R SYMON, Univ. of Wis. Addison-Wesley Publishing Co Inc, Reading, Mass. 6 x 9, 557 pp. $10.75

A textbook for an advanced undergraduate course in mechanics which provides a foundation for advanced courses in physics. The choice of topics and their treatment emphasize the modern point of view; applications

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to atomic physics are made wherever possible.

Topics covered are: Newtonian mechanics; particle in one, two or three dimensions; motion of a system of particles; rigid bodies; gravitation; moving coordinate systems; mechanics of continuous media; Lagrange's equations; tensor algebra, inertia and stress tensors; rotation of a rigid body; and theory of small vibrations.

ABSTRACTS

What do you know about moduli?

The various expressions of modulus in materials and mechanical systems are discussed, as a guide to further study and for the purpose of simplifying calculations.

"What Do You Know About Moduli?" Design Engineering, Oct 1961, 481 *University Ave, Toronto 2, Canada.*

Pipe and tube strengths

Performance of pipes and tubes carrying internal pressure is directly and simply related to the maximum permissible material stress and pipe geometry. Material stress is temperature dependent in the case of nonferrous metal tubes and plastic tubes. In the latter materials, glass-reinforced pipes offer a comparable performance to buttwelded mild steel.

"Pipe and Tube Strengths in Different Materials," Mechanical World and Engineering Record, Sep 1961, *Mechanical World,* 31 *King St W, Manchester* 3, *London.*

Dynamic balance of initially bent shafts

Applies Jeffcott's theory to the treatment of shafts with permanent static flexural distortion. Also discusses influence of locality of action of viscous damping.

"Dynamic Balance of Initially Bent Shafts," by J. Morris. Mechanical World, Oct 1961, 31 *King Street West, Manchester* 3, *England.*

Vibration of beams

Rayleigh equations are given for calculating fundamental frequency of bending vibration of a heavy beam with and without concentrated loads.

"Vibration of Beams in Bending," W. Carnegie, head of the department of civil and mechanical engineering, Battersea College of Advanced Technology, Engineering Materials and Design, Oct 1961, *Heywood & Company Ltd, Drury House, Russell St, London, WC2.*

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 175.

UNIVERSAL JOINTS—Bulletin 513, 6 pp. Describes performance characteristics for heavy-duty applications. Covers four sizes with torque capacities ranging from 4,250 to 12,700 lbs.-ft. Dimension drawings included. Twin Disc Clutch Co, Hydraulics Div, Rockford, Ill.
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METER-RELAYS—Bulletin 5, 23 pp. Includes operating features and standard circuits for continuous reading meter-relay, which requires no reset. Also covers isolated coils, double locking coils, response time and damping, overload protection and control components used. Specifications and dimensions are reviewed. Assembly Products Inc, Chesterland, Ohio.
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VINYL SHEETING—Booklet, 4 pp. Gives complete physical properties

continued, page 159

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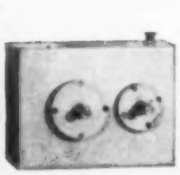

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and chemical resistance tables as well as information on fabrication, cementing, vacuum forming and lamination. Also lists the general properties for rigid vinyl and discusses its wide range of applications. Nixon-Baldwin Chemicals Inc, Nixon, NJ.

Circle 362 on Reader Service Card

INSERTION OF NYLON PELLETS—Brochure, 4 pp. Details contract service for inserting locking pellets into all types of nuts and press fit parts. Contains diagrams and data covering standard threaded part processing and reviews design features. Nylok-Detroit, 1893 Barrett Rd, Troy, Mich.

Circle 363 on Reader Service Card

SYNCHRONOUS MOTORS—Bulletin GEA-7332, 2 pp. Reviews performance characteristics and describes features of synchronous reluctance motors, rated 1-5 hp, 220/440 v, three-phase, 60 cps. Contains consolidated rating and performance chart with dimension diagrams. Cutaway illustrates construction. General Electric Co, Schenectady 5, NY.

Circle 364 on Reader Service Card

FLUOROSILICONE LUBRICANTS—Bulletin 15-200, 15-201, 15-202, 4, 2 and 2 pp each. Discusses properties of these lubricants as fluids, compounds and greases. Suggests applications for these fuel and chemical-resistant materials. Performance charts and graphs give lubricity, insolubility and temperature range. Dow Corning Corp, Midland, Mich.

Circle 365 on Reader Service Card

ELECTRIC HEATERS — Bulletin 600, 4 pp. Includes specifications for temperature ranges, wattage and suggested applications for immersion, cartridge, strip, tubular and infra-red units. Also contains accessory items with single and dual temperature controls, simple snap switches, and adjustable thermostats. Heatrex Inc, Meadville, Pa.

Circle 366 on Reader Service Card

WIRE CLOTH—Catalog R-100, 28 pp. Contains description of weave types, mesh size vs open area tables, weight listings, application principles, and guides to the selection of proper metals and protective coatings. National-Standard Company, Dept RDT, Niles, Mich.

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ELECTRO-MECHANICAL COMPONENTS—Catalog 100, 140 pp.

continued, page 161

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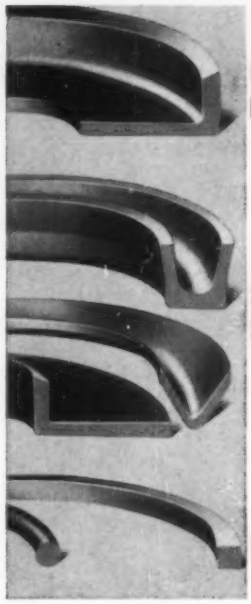

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CIRCLE 73 ON READER SERVICE CARD

Outlines specifications and dimensions of such items as precision gears, magnetic clutches and brakes, differentials, couplings, gear heads, limit stops, bearings and electronic hardware. Price charts and dimension drawings are given. Also reviews design, performance and mechanical properties of each unit. Siamco, Div of Tech-Ohm Electronics, Inc, LI, NY.

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PRECISION MOTORS—Catalog, approx 25 pp. Describes and illustrates 25 AC and DC precision motors available in a complete range of sizes from .001 to 7.5 hp. Also includes design features, complete specifications consisting of input and output voltage, size and weight and insulation data. Application data, performance curves and engineering drawings are given. Eicor Div, Indiana General Corp, 517 W Walnut St, Oglesby, Ill.

Circle 369 on Reader Service Card

FLEXIBLE METAL HOSE—Bulletin 15-E, 6 pp. Describes interlocked pressure hose for loading, unloading and conveying steam, oil, tar and asphalt. Also contains charts showing specifications, working pressure correction factors and typical assemblies that are available. Atlantic Metal Hose Co, Inc, 308 Dyckman St, New York 34.

Circle 370 on Reader Service Card

MULTI-CIRCUIT SWITCHES—Bulletins 6130 and 6131, 4 pp each. Describes design, characteristics and application of monoplanar selector switches based on flat printed circuits and linear drive mechanisms. Ucinite Co, Div United-Carr Fastener Corp, Newtonville 60, Mass.

Circle 371 on Reader Service Card

BIMETAL THERMOMETERS — Catalog 09-100, 16 pp. Discusses design, performance characteristics and specifications of approximately 10 thermometers, according to ranges, sizes, and types. For use in alarm and control systems, maximum-minimum indication and other uses. Weston Instruments Div, Daystrom Inc, 614 Frelinghuysen Ave, Newark 14, NJ.

Circle 372 on Reader Service Card

LAMINATED PLASTICS — 1962 Condensed catalog, 8 pp. Reviews standard laminated plastics, reinforced plastics, copper-clad laminates, vulcanized fibre and filament-wound structures. Also lists suggested applications, corresponding NEMA grades, military specification, color,

continued, page 163

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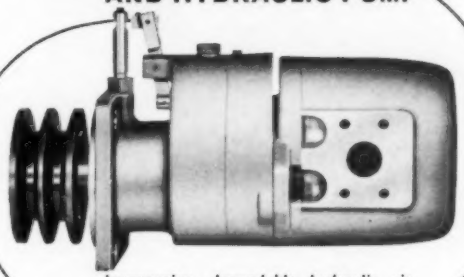

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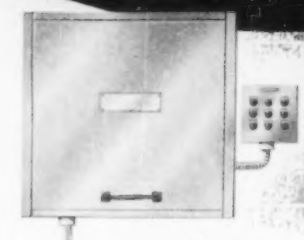

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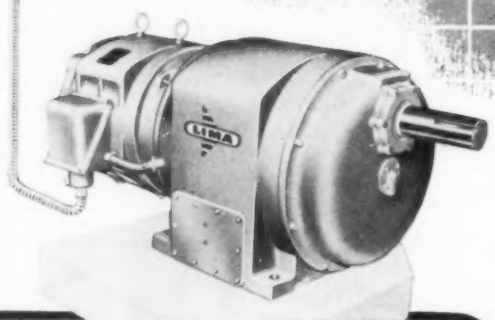

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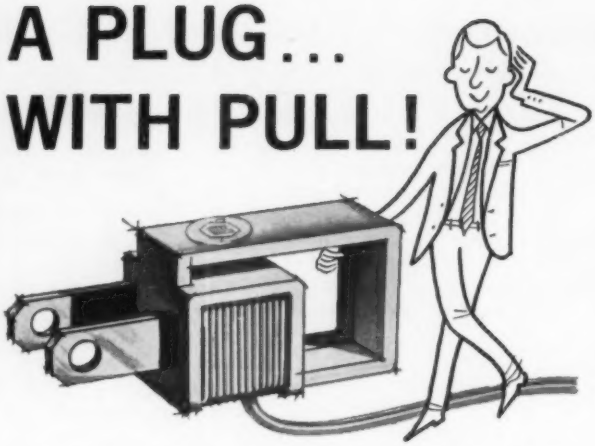

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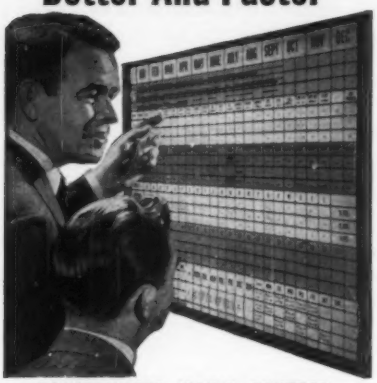

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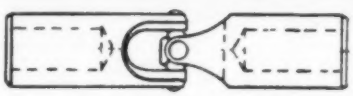

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4BS	.1875	9/32	1-3/8	64	5.75
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DESIGN LITERATURE

forms and sizes in which 25 of the most common grades are furnished. Contains tables outlining physical, mechanical, and electrical properties. Taylor Fibre Co, Norristown, Pa.

Circle 373 on Reader Service Card

FOOTSWITCHES—Catalog 62, 8 pp. Describes power footswitches consisting of light and heavy-duty construction with momentary and maintained contact plus rockertype actuation with a mechanical interlock between circuits. Linemaster Switch Corp, 432 Woodstock Terrace, Woodstock, Conn.

Circle 374 on Reader Service Card

HEAT RESISTANCE — Brochure, approx 9 pp. Covers process of deeply diffusing aluminum into steel to form an iron-aluminum protective alloy which will increase life of the steel, under heat, from 10 to 20 times. Performance characteristics and physical properties are reviewed and comparative bar charts show results of oxidation tests at elevated temperatures. Alon Processing Inc, Pittsburgh, Pa.

Circle 375 on Reader Service Card

NON-FERROUS ALLOYS— Bulletin 100, 4 pp. Outlined on master chart are 40 non-ferrous alloys which are reviewed according to nominal chemical compositions, mechanical properties and governmental and society specifications. Wisconsin Centrifugal Foundry, 905 E St Paul Ave, Waukesha, Wis.

Circle 376 on Reader Service Card

PISTON PUMPS & MOTORS—Bulletin 61-81, 2 pp. Covers heavy-duty units available with fixed or variable displacement. Provides application data and standard control and includes curves showing typical performance characteristics. Vickers Inc, Div Sperry Rand Corp, Detroit 32.

Circle 377 on Reader Service Card

VALVE SIZING—Technical Paper, 4 pp. Discusses undersized, oversized and correctly sized pressure-reducing applications. Also gives illustrations showing advantages of correct sizing along with normal, minimum and maximum flow capacity. Jordan Valve, Div Richards Industries, Inc, 6013 Wiehe Rd, Cincinnati 37, Ohio.

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FLUID & RFI SEAL—Data sheet. Describes gasket and seal material consisting of knitted wire-mesh radio frequency interference shield integral with adhesive-backed sponge neoprene

continued, page 165

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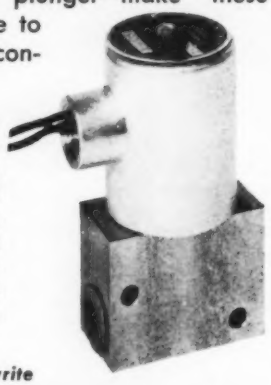

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seal. Details applications, control rating, installation time, specs and prices. Technical Wire Products Inc, 129 Dermody St, Cranford, NJ.
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CAMS AND CAMSHAFTS—Bulletin 210, 6 pp. Describes and illustrates face and cylindrical cams, two and three dimensional cams, aircraft cams, master cams and hydraulic pump cams. Eonic Inc, 464 E Hollywood, Detroit 3.
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ADJUSTABLE SPEED DRIVES—Bulletin 110, 2 pp. Describes and illustrates the synchro-range drive, which is a packaged system consisting of an adjustable frequency power supply, two or more synchronized motors of the same or different hp ratings and a control panel. Gives operation features and contains a specification chart showing comparisons between adjusto-spede and magnetic drive power supply. Louis Allis Co, Dept. P, 427 E Stewart, Milwaukee.
Circle 381 on Reader Service Card

TEXTILE FIBERS — Comparison chart, 4 pp. Reviews resistance features of all generic fibers to acids, alkalies, salts, solvents, oxidizing agents and also indicates concentration and temperature and extent to which fiber resists chemical change. Filtration Fabrics Div, American Machine & Metals Inc, E. Moline, Ill.
Circle 382 on Reader Service Card

EPOXY RESINS—Technical bulletins—series 1000. Lists properties of nine potting compounds, describes methods of encapsulating and potting critical parts and assemblies, and also details procedures for cleaning, techniques for repairing and patching parts and stripping methods to use to salvage components. Bacon Industries Inc, 192 Pleasant St, Watertown 72, Mass.
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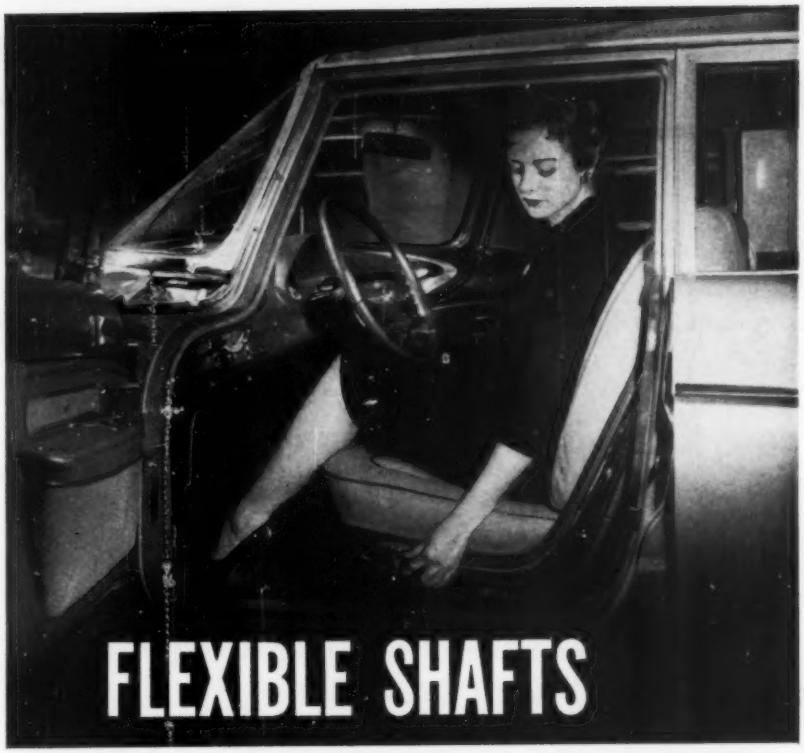
VERTICAL & ROLL FILES—Catalog 3-60, 18 pp. Details design features and dimension charts for wall racks, swingaway racks, data files, rolling stands, cabinets, pocket files, etc. Plan Hold Corp, 5204 Chakemco St, S Gate, Calif.
Circle 384 on Reader Service Card

OPTICAL TERMINOLOGY—Glossary, 1 p. Designed for use as reference by engineers, it covers a wide range of technical terms from "aberrations" to "surface reflection." Also
continued, page 167



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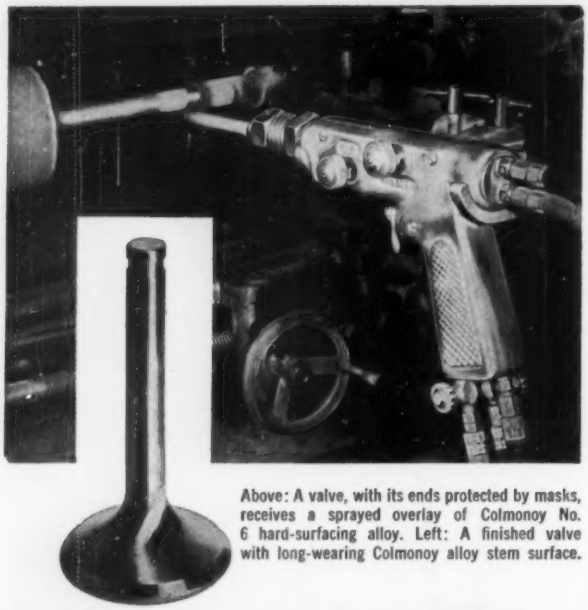

Above: A valve, with its ends protected by masks, receives a sprayed overlay of Colmonoy No. 6 hard-surfacing alloy. Left: A finished valve with long-wearing Colmonoy alloy stem surface.

Colmonoy Spraywelder Builds Longer Life into Aircraft Valve

To overcome corrosive pitting and abrasion of aircraft engine valve stems, more than one manufacturer has chosen Colmonoy No. 6 alloy to provide a long wearing stem surface. Colmonoy No. 6 stops the pitting and excessive wear which necessitates frequent engine overhauls. The Colmonoy Spraywelder is used to apply the powdered alloy. It works fast and makes smooth, controlled-depth overlays that finish up in minimum time.

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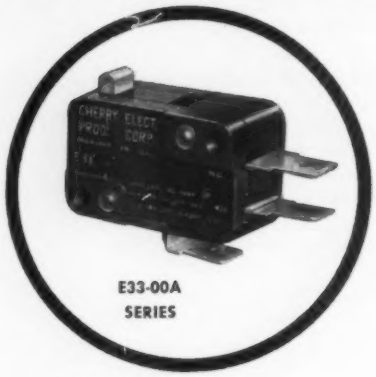

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CIRCLE 82 ON READER SERVICE CARD

describes and illustrates infrared optics and other advanced electronic instruments. Servo Corp of America, 111 New S Road, Hicksville, LI, NY.
Circle 385 on Reader Service Card

FASTENERS—Folder, approx 8 pp. Illustrates more than 80 intricate screws, bolts, washers and rivets and also includes the company's line of thread protectors for tubular goods used in oil and gas operations. Gives complete specifications as to types of finishes, raw materials used and production equipment data, and includes an equipment capacities chart. Screw & Bolt Corp of America, PO Box 1708, Pittsburgh 30, Penna.
Circle 386 on Reader Service Card

BALL VALVES—Bulletin PB 911, 4 pp. Reviews performance characteristics and lists complete operating and application features with specifications and blueprint drawings. General Kinetics Corp, 197 S Van Brunt St, Englewood, NJ.
Circle 387 on Reader Service Card

ROTARY SELECTOR SWITCH—Leaflet 7, 2 pp. Describes design features and functional versatility of remotely controlled selector switches and illustrates by way of sketches performance characteristics of units. Ledex Inc, 123 Webster St, Dayton 2, Ohio.
Circle 388 on Reader Service Card

FRICTION WHEEL BRAKES—Brochure LJ-75. Contains ratings, wheel data and dimensions of A-C solenoid-operated brakes, and lists many of construction features of devices which provide them with long mechanical life. Illustrations and drawings are offered. Cutler-Hammer Inc, 296 N 12 St, Milwaukee 1.
Circle 389 on Reader Service Card

SOUND & VIBRATION INSTRUMENTS—Catalog ES-10, 24 pp. Supplies detailed information on resistance, inductance, capacitance, temperature ranges, etc. Reviews accelerometers, amplifiers, deviation bridges, filters, level recorders, strain gauge equipment, and many other units outlining design features and mechanical specifications. B & K Instruments Inc, 3044 W 106 St, Cleveland 11.
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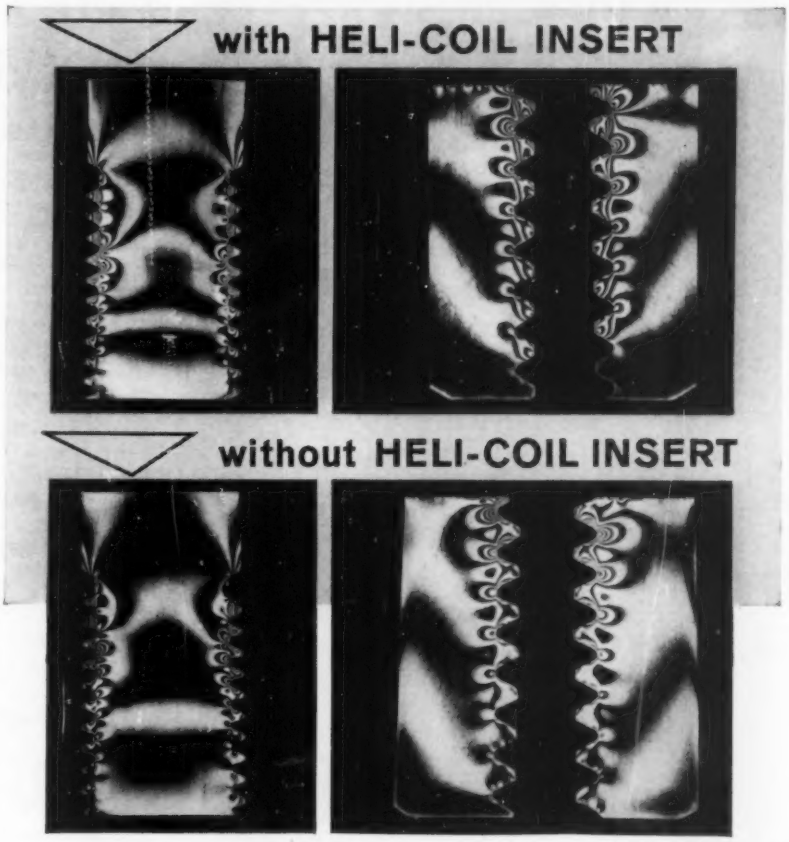
CIRCUIT MODULES — Catalog, 47 pp. Provides data on circuit modules, which operate over an ambient temperature range of −55°C to +71°C.
continued, page 169

How HELI-COIL® Stainless Steel Wire Inserts Eliminate Stress Concentration and Insure Maximum Strength in Threaded Assemblies



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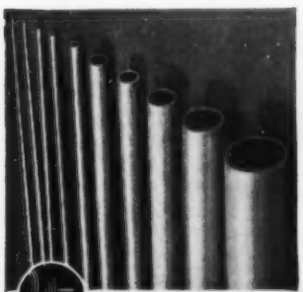

UNIFORM TUBES, INC. COLLEGEVILLE 2, PA.
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DESIGN LITERATURE

Details electrical, mechanical and environmental specifications and includes a price list and loading chart. Electronic Modules Corp, 1949 Greenspring Drive, Timonium, Md.
Circle 391 on Reader Service Card

VANE PUMPS—Bulletin 200A 4 pp. Discusses use and operating characteristics of hydraulic pumps at pressures up to 2500 psi, and covers a variety of possible applications. Included are performance and efficiency charts, schematic diagrams. Denison Engineering Div, American Brake Shoe Co, 1160 Dublin Rd, Columbus, Ohio.
Circle 392 on Reader Service Card

ASBESTOS FELT FOR MOLDING—Bulletin TX-10A, 2 pp. Discusses physical characteristics of asbestos in sheet form, consisting of a non-cured, non-woven material. Also contains technical data, application data and tabular information including mechanical, thermal, and electrical properties. Johns-Manville, 22 E 40 St, New York 16.
Circle 393 on Reader Service Card

MINIATURE SOLDER CONNECTORS—Catalog BSB, 24 pp. Includes specifications, dimensional drawings, tables, shell styles, and termination devices for nine shell sizes—8 through 24. Explains polarization and presents a master chart with line drawings and photographs keyed to the dimension tables. Burndy Corp, Norwalk, Conn.
Circle 394 on Reader Service Card

STRAIN GAGES & ACCESSORIES—Catalog BG-2200, 20 pp. Discusses design features of backed, dynamic and high temperature gages and details performance characteristics of each. Included are performance curves showing the difference between compensated and stabilized gages, and information covering installation procedures. Also reviewed are basic kits used to install the strain gages, including temperature ranges, and dimension outline drawings. Budd Co, Budd Instruments Div, Phoenixville, Penna.
Circle 395 on Reader Service Card

PRESSURE REGULATING VALVES—Bulletin SM 71, 8 pp. Discusses design features of balance, pilot operated, and direct acting valves, and offers service data, connecting pipe sizes, construction specifications, applications, and operation details for each valve. Included are charts list-

continued, page 171

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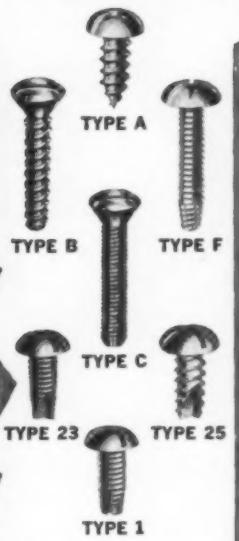

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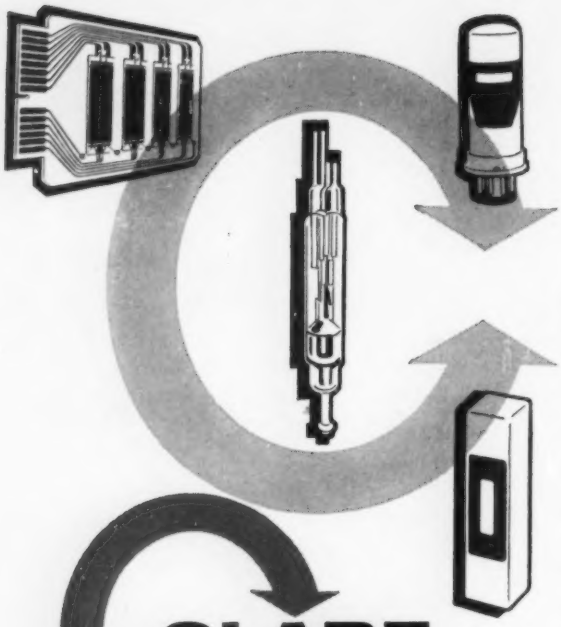

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ing dimensions, weights and prices of each unit and also short descriptions of reducing, regulating and block steel valves. Strong, 508 Sandusky St, Conneaut, Ohio.

Circle 396 on Reader Service Card

OPTICAL EQUIPMENT — Catalog 621, 160 pp. Included are measuring magnifiers, pocket comparators, illuminators, projection sets, and other instruments and components for checking, measuring and comparing. Also reviews microscopes, telescopes and accessories, lenses, binoculars and photographic items. Edmund Scientific Co, Barrington, NJ.

Circle 397 on Reader Service Card

MICA COATED INSULATING TAPE—Catalog, 8 pp. Supplies actual samples of all standard tapes and reviews electrical and mechanical specifications. Also explains process by which mica coatings are deposited on fiberglass or Mylar. Mica-Coated Products Div, McMillan Laboratory Inc, Brownville Ave, Ipswich, Mass.

Circle 398 on Reader Service Card

WIDE CAPACITY WHITEPRINTER—Bulletin, 4 pp. Describes and illustrates design and operating details of 42-in. capacity budget-priced unit. Specifications, dimensions and weights are included. Ozalid Div, General Aniline & Film Corp, Johnson City, NY.

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WELDING SYMBOLS CHART—Wall chart, 8½ x 11 in. Includes basic weld symbols and location significance, supplementary symbols used with welding symbols and identification of basic joints, including arrow side and other side of joint. Lenco Inc, 350 W Adams St, Jackson, Mo.

Circle 400 on Reader Service Card

DC CONNECTOR KIT—Catalog, 10 pp. Covers subminiature coaxial connectors, describing and illustrating performance characteristics, contact reliability and quick-disconnect operation. Also provides assembly procedures. Deutsch Co, Electronic Components Div, Municipal Airport, Banning, Calif.

Circle 401 on Reader Service Card

WELDABLE STRAIN GAGES—Data sheet 4324, 2 pp. Reviews Bakelite and ceramic-bonded types, with strain range of ±½% (±5000 microin./in.). Also gives temperature coef curves, shows variation of gage factor with temperature, and

continued, page 173

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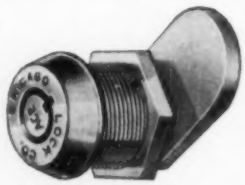

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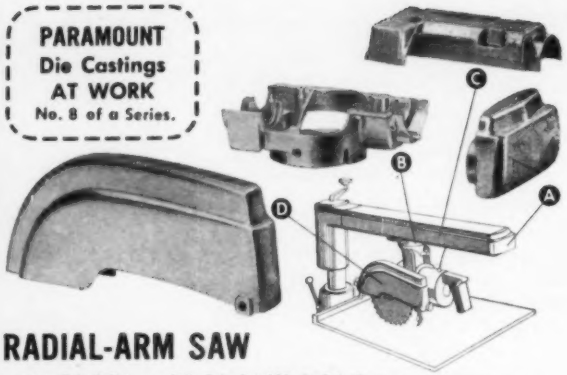

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provides design and application data and prices. Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, Waltham, Mass.

Circle 402 on Reader Service Card

REINFORCED PLASTIC—Bulletin 8.4, 4 pp. Lists forms available in the asbestos-base laminated plastic that exhibits noteworthy ablation properties and underscores typical values for physical, mechanical and thermal properties. Also discusses oxy-acetylene torch and blast resistance tests made on the material. Taylor Fibre Co, Norristown, Penna.

Circle 403 on Reader Service Card

GEARS, SPEED REDUCERS—Brochure, 4 pp. Pictures custom gear products and condenses specifications to indicate available tooling. Ohio Gear Co, 1333 E 179th St, Cleveland 10.

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CYLINDER LOCK VALVES—Data sheets 37.1 and 37.2, 2 pp. each. Contain specifications, flow charts, dimensions, schematic drawings, typical circuit applications, approved JIC symbols and other design information on function and operation of valves. Sarasota Precision Products Inc, 5757 McIntosh Rd, Sarasota, Fla.

Circle 405 on Reader Service Card

FRICTION MATERIALS—Brochure FM-57A, Deals with asbestos brake blocks, linings, clutch facings, bushings, bearings and molded parts. Provided are charts outlining material selection, characteristics and recommendations. Materials for special applications are discussed and methods of attaching are explained. Johns-Manville, Packing & Friction Materials Div, 22 E 40th St, New York 16.

Circle 406 on Reader Service Card

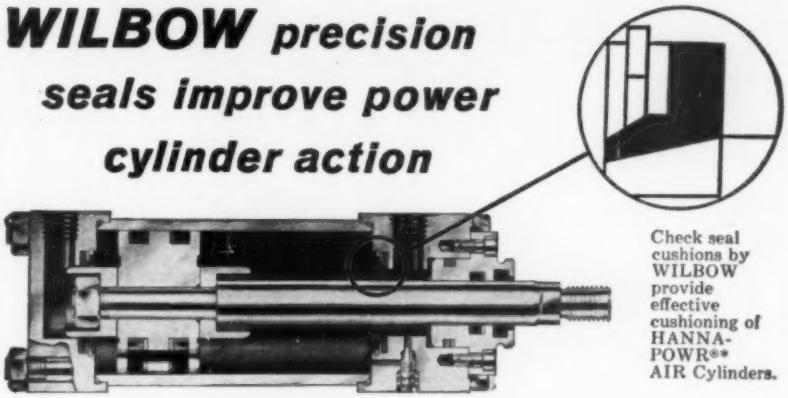
SELF - SEALING FASTENERS — Catalog H61, 4 pp. Describes and illustrates four types for critical high-pressure sealing applications. Reviewed are specifications, including temperature and pressure ranges, corrosion resistance, sizes and styles. APM Corp, 41 Honeck St, Englewood, NJ.

Circle 407 on Reader Service Card

BEARINGS—Bulletin 7104, 12 pp. Carries dimensions, dimension drawings and design features of permanently lubricated ball bearing pillow blocks, flange units and takeup units, as well as porous bronze and babbitted

continued, page 175

WILBOW precision seals improve power cylinder action



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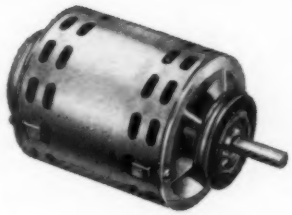

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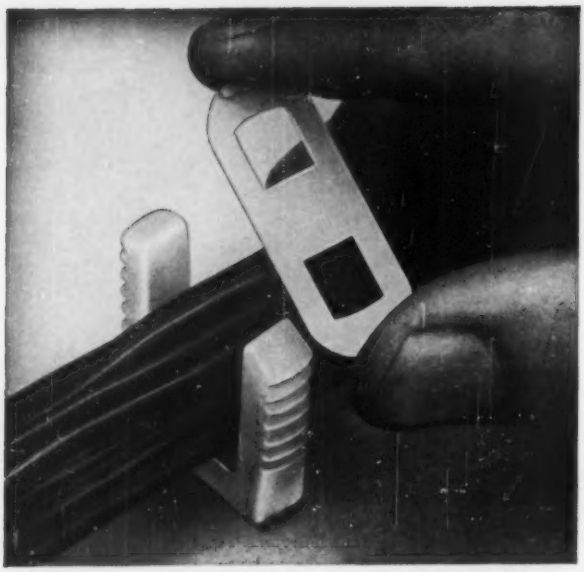

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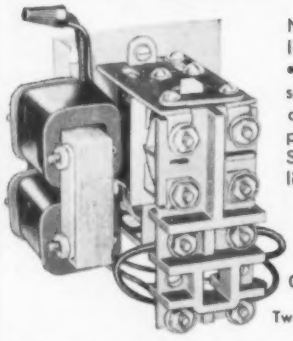

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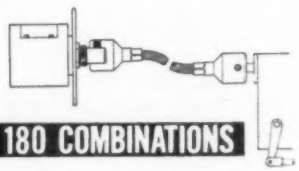

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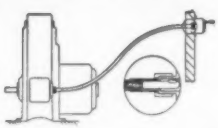

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Manufacturers who published following literature asked that requests for copies be made on company letterheads.

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SCIENCE & ENGINEERING — Booklet, 30 pp. As a guidebook for parents, it outlines characteristics which may indicate an embryo engineer or scientist, and also suggests academic and associated activities which help to develop interest in these professions. Covers such subjects as where to seek specific counsel, possible financial aid, and possibility of student working his way through college. Also stresses importance of science-oriented courses and appreciation of it in our lives. Battelle Memorial Institute, Columbus, Ohio.

SILICONE COMPOUNDS—Technical Data Book S-23, 16 pp. Discusses two types of silicone materials for potting, embedding and encapsulation of electrical and electronic equipment. Provides full information on silicone rubber compound and the new, resilient transparent material which provides continual inspection and easy repair of potted assemblies. Also covered are typical physical and electrical properties. Silicone Prod Dept, General Electric Co, Waterford, NY.

STAINLESS STRIP STEELS—Brochure, 32 pp. Provides a guide to selection of various stainless grades for specific applications. Technical data, physical and mechanical properties, heat treating and finishing of 19 stainless steel types are provided, plus visual presentations of applications in the automotive, architectural, household and other fields. Cleaning procedures and weight tables are included. Superior Steel Div, Copperweld Steel Co, Carnegie, Penna.

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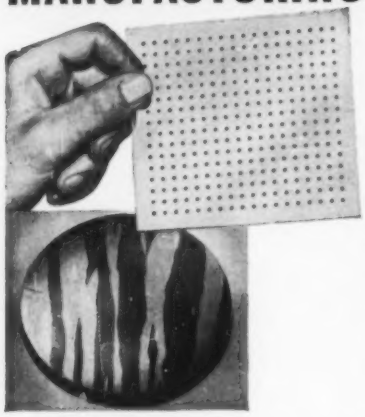

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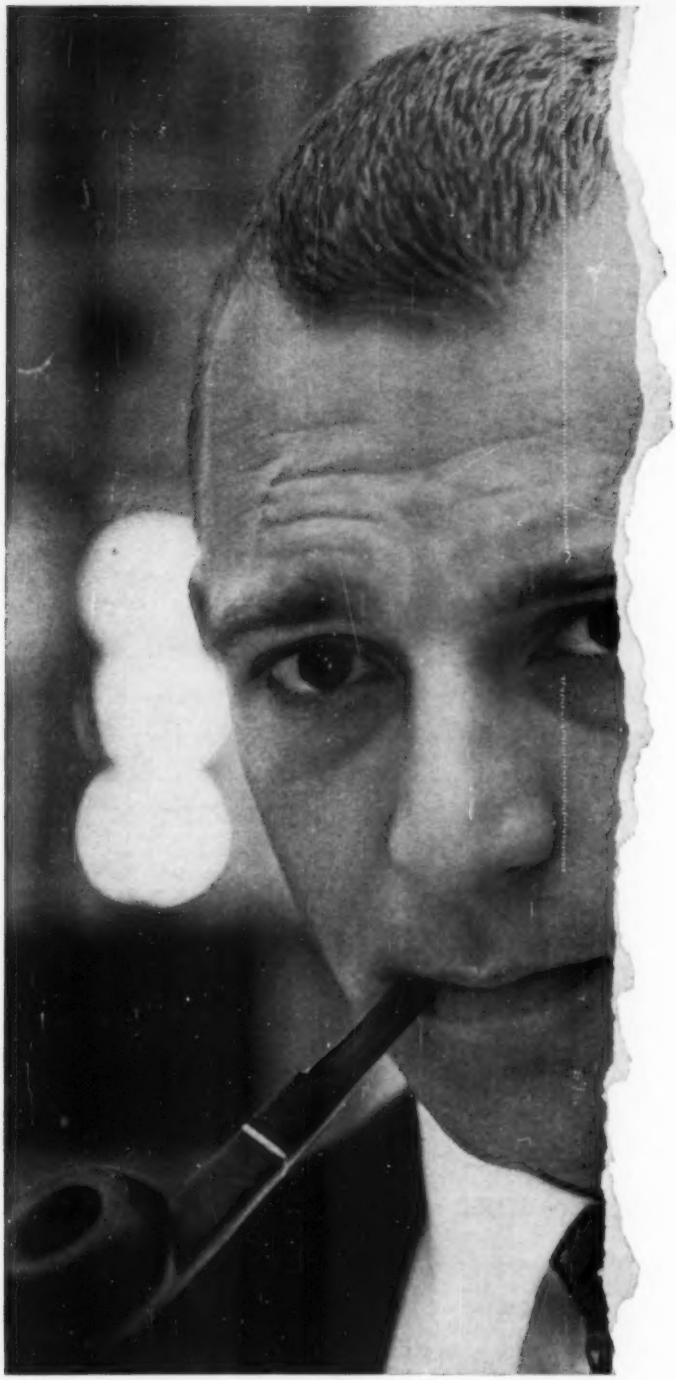

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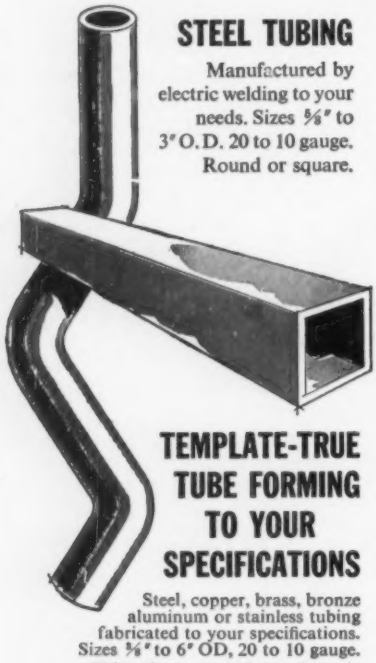

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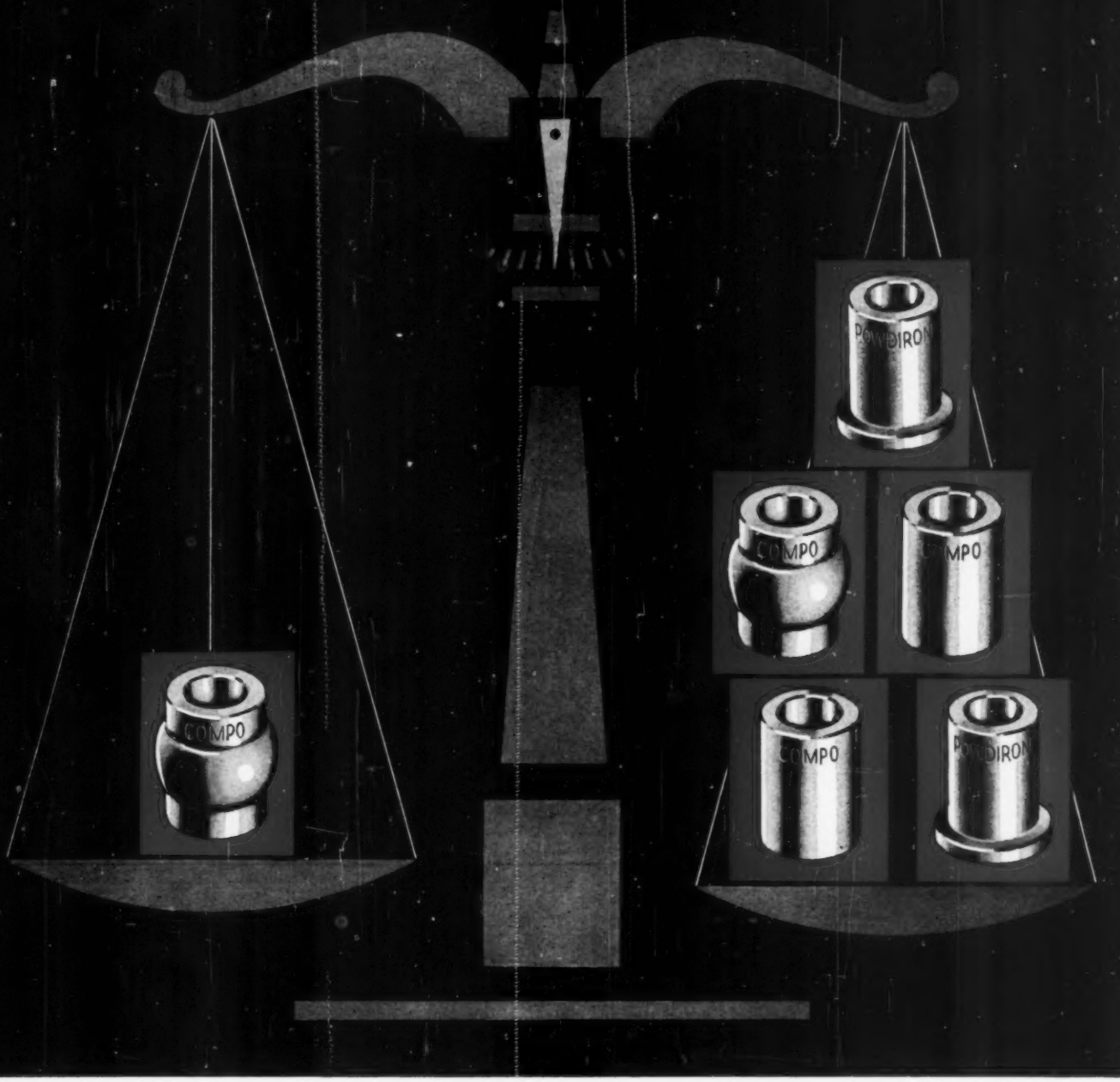

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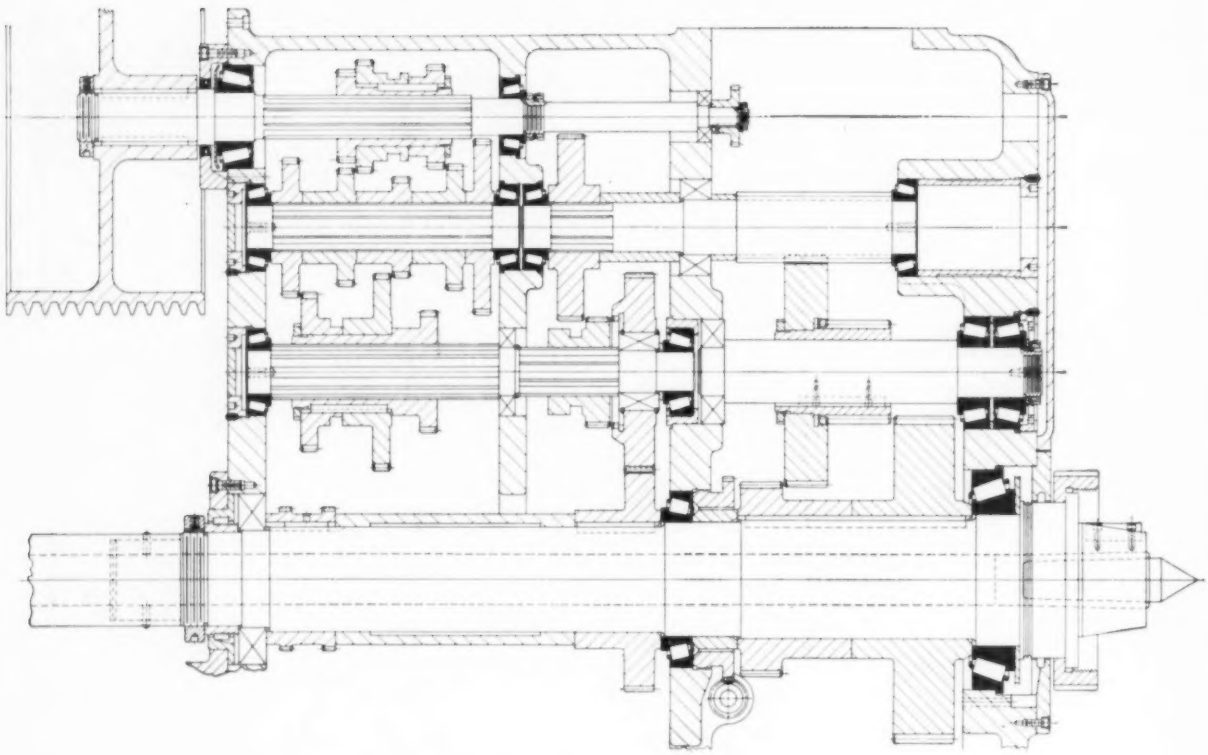

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